Biological Resources Division, Santa Cruz Field Station

August 9, 2018

AUG 1 5 2018

Dear Anna and Mary:

Enclosed you will find our application for the renewal and amendment of our current permit #MA672624-20, due to expire September 12, 2018. The Application for Renewal (Form 3-200-43) is included. In order to provide the most complete information possible, we have attached 33 additional pages to Form 3-200-43 starting with Section E.

Please note that we are not requesting any changes to our current permit, other than to add 3 people to the list of co-investigators. Their qualifications and CV's are found within. Furthermore, we are only requesting to carryover our number of takes (606 total captures left on existing permit) from our previous permit, and not requesting new takes.

In additional to the main permit application, we've included a full copy of our current IACUC. A three-page list of relevant publications that have stemmed from previous versions of our current FWS permit is also included for your reference.

Three separate research proposals for sea otter studies that are currently in progress under our existing permit have been enclosed in accordance with question 18 in the application.

Please note that we are currently planning to preform sea otter recapture operations this October in support of one of our 3 on-going projects (Monterey NSF Predator Diversity Study). We are requesting permission to continue our research operations under an extension of our current permit, should the renewal not get processed by October.

If you have any questions or require any additional information, please do not hesitate to contact myself or Brian Hatfield, of the U. S. Geological Survey. Contact information is as follows:

Joe Tomoleoni: 831-254-9750, jtomoleoni@usgs.gov
Brian Hatfield: 805-305-2121, brian_hatfield@usgs.gov

Sincerely,

Joseph Tomoleoni

Enclosure

Long Marine Laboratory, UCSC
115 McAllister Way
Santa Cruz, CA 95060
Phone: (831) 254-9750

Form 3-200-43

OMB Control No. 1018-0093
Expires 08/31/2020

AUG 1 5 2018

Department of Interior
U.S. Fish and Wildlife Service
Federal Fish and Wildlife Permit Application Form

U.S. Fish and Wildlife Service
Division of Management Authority
Branch of Permits, MS: IA
5275 Leesburg Pike
Falls Church, VA 22041-3803
1-800-358-2104 or 703-358-2104

Type of Activity

Take/Import/Export of Marine Mammals for Public Display, Scientific Research, Enhancement, or Rescue/Rehabilitation/Release Activities or Renewal/Amendment of Existing Permit (*MMPA and/or ESA*)

Complete Sections A or B, and C, D, and E of this application. U.S. address may be required in Section C, see instructions for details.
You may find instructions on how to make your application complete and help avoid unnecessary delays at the following link:

Section A: Complete if applying as an individual

1.a. Last Name	1.b. First Name	1.c. Middle Name/Initial	1.d. Suffix
Tomoleoni	Joseph	A	

[redacted]dd/yyyy)	3. Telephone Number	3.a. Alternate Telephone Number	4. E-mail address
	831-254-9750		jtomoleoni@usgs.gov

Section B: Complete if applying on behalf of a business, corporation, public agency, Tribe, or institution

1.a. Name of business, agency, Tribe, or institution	1.b. Doing business as (DBA)
2. Tax identification no.	3. Description of business, agency, Tribe, or institution

4.a. Principal officer Last name	4.b. Principal officer First Name	4.c. Principal officer Middle name/initial	4.d. Suffix

5. Principal officer title	6. Primary contact name

7.a. Business telephone number	7.b. Alternate telephone number	7.c. Business fax number	7.d. Business e-mail address

Section C: All applicants complete address information

1.a. Physical address (Street address; Apartment #, Suite #, or Room #; no P.O. Boxes)
115 McAllister Way

1.b. City	1.c. State	1.d. Zip code/Postal code	1.e. County/Province	1.f. Country
Santa Cruz	CA	95060	Santa Cruz	USA

2.a. Mailing address (include if different than physical address; include name of contact person if applicable)

2.b. City	2.c. State	2.d. Zip code/Postal code	2.e. County/Province	2.f. Country

Section D: All applicants MUST complete

1. **Attach the non-refundable application processing fee**, in the form of a check or money order, payable to the U.S. FISH AND WILDLIFE SERVICE **in the amount identified on page 3.** Federal, Tribal, State, and local government agencies, and those acting on behalf of such agencies, are exempt from the processing fee – *attach documentation of fee exempt status as outlined in instructions.* [50 CFR 13.11(d)].
2. Certification: I hereby certify that I have read and am familiar with the regulations contained in ***Title 50 Part 13 of the Code of Federal Regulations*** and the other ***applicable parts in subchapter B of Chapter I of Title 50***, and I certify that the information submitted in this application for a permit is complete and accurate to the best of my knowledge and belief. I understand that any false statement herein may subject me to the criminal penalties of 18 U.S.C. 1001.

Signature of applicant/Principal Officer for permit (No photocopied or stamped signatures)	Date of signature (mm/dd/yyyy)
Joseph A. Tomoleoni	08/09/2018

Please continue to next page

E. Take/Import/Export of Marine Mammals for Public Display, Scientific Research, Enhancement, or Rescue/Rehabilitation/Release Activities or Renewal/Amendment of an Existing Permit (Species listed in the MMPA and/or species listed in both the MMPA and ESA)

Allow at least 90 days for the application to be processed. Applications for marine mammal permits must be published in the Federal Register for a 30-day public comment period.

Use this application for the take[1], import, export, or re-export of marine mammal species (or their parts) under the jurisdiction of the U.S. Fish & Wildlife Service (sea otters, marine otter, polar bears, walrus, manatees, and dugongs; see the marine mammal policy fact sheet) for purposes of public display of live animals, scientific research, or enhancement under the U.S. Marine Mammal Protection Act (MMPA) and/or U.S. Endangered Species Act (ESA). This application may also be used to apply for a letter of authorization (LOA) under MMPA Sections 109(h)/112(c) and/or an ESA permit for enhancement of propagation or survival of the species, which would provide authorization to work as a "cooperator" for the purpose(s) of **rescue, rehabilitation, and/or release of stranded marine mammals.** Finally, this application may be used for the **renewal and/or amendment** of an existing permit for these activities.

Note: Renewal and amendment requests require responses to all questions pertaining to your requested activity.

This form should NOT be used:

- For activities involving marine mammals under jurisdiction of the National Marine Fisheries Service (NMFS) (i.e., whales, dolphins, porpoises, seals, and sea lions), please contact NMFS.
- For activities involving photography in the wild for educational or commercial purposes, use Form 3-200-86.
- For transport/transfer of live captive-held animals within the United States, use Form 3-200-87.
- For transfer within the United States of dead marine mammal specimens for the purpose of public display or scientific research, use Form 3-200-87.

If you already have MMPA/ESA authorization and need a CITES permit:

- For CITES export/re-export of captive-held **LIVE** animals, use Form 3-200-53.
- For, export, or re-export of parts or biological samples, use Form 3-200-29; for import of parts of Appendix-I animals, use Form 3-200-37; and for introduction from the sea, use Form 3-200-31.
- Provide a copy of your FWS or NOAA Fisheries permit or authorization with your CITES permit application.

All international shipment(s) must be through a designated port. A list of designated ports (where an inspector is posted) is available from the list of designated ports. If you wish to use a port not listed, please contact the Office of Law Enforcement for a Designated Port Exemption Permit (form 3-200-2).

[1] The term, "take," as defined by the MMPA means to harass, hunt, capture, or kill, or attempt to harass, hunt, capture, or kill any marine mammal. As defined by the ESA, "take" means to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct.

PERMIT TYPES AND PROCESSING FEES

Please review the complete application carefully before beginning. Provide complete answers to all the questions in the sections relevant to the activity for which you are requesting authorization. If a question is not applicable, answer with "N/A." You will need to use additional sheets of paper. On all attachments or separate sheets you submit, indicate the application question number you are addressing. If you are applying for multiple species and/or activities, be sure to indicate which species/activity(ies) you are addressing in each response.

Electronic submission of inventories, photographs, and receipts: Some applications contain extensive inventories and/or a large number of photographs or receipts. You may provide electronic versions of the documents. Such a submission will assist in the processing of your application since it may reduce data entry by the U.S. Fish and Wildlife Service. If you wish to provide information electronically, once you have received an application number via the e-mailed acknowledgement letter, e-mail your information to Permits@fws.gov. Be sure to include the application number provided in the acknowledgement e-mail that will be sent to you when we receive your application.

☐ **I will be submitting documents electronically.**

PURPOSE for which you are applying (check below):

☐ PUBLIC DISPLAY of live animals (Processing Fee = $300): **Complete All of Part I and Part II.**

NOTE: A public display permit is not available for marine mammal species listed as depleted under the MMPA or listed under the ESA; a public display permit may be valid for the life of an animal and is not renewable; a public display permit may be available for a facility that would hold multiple animals of a particular species and would be renewable every 5 years.

☑ SCIENTIFIC RESEARCH (Processing Fee = $150): **Complete All of Part I and Part III.**

☐ RESCUE, REHABILITATION, and/or RELEASE of stranded marine mammals (Processing Fee = $150): **Complete questions 1-7 of Part I and Part IV.**

☐ MMPA ENHANCEMENT of survival or recovery of the species or stock (Processing Fee = $150): **Complete Part I and Part V.**

Request is for (check below):

☐ NEW PERMIT (See processing fee above).

☑ RENEWAL of Permit # MA672624-20 (See processing fee above; Complete all questions for your requested activity, as described above).

☐ AMENDMENT of Permit # ____________ (For Scientific Research, Rescue/Rehabilitation/Release, or MMPA enhancement, amendment fee = $75, and for Public Display = $150).

If requesting renewal or amendment of your current permit, provide an update of any activity that has occurred under the permit since your last report.

PART I.

1. Name and address where you wish the permit to be mailed, **if different from page 1**. If you would like expedited shipping, please enclose a self-addressed, pre-paid, computer-generated, courier service airway bill. If unspecified, all documents will be mailed via the U.S. Postal Service.

   same address as Page 1

2. Who should we contact if we have questions about the application (name, phone number, and e-mail)?

   First contact: Brian Hatfield, 805-305-2121, brian_hatfield@usgs.gov
   Secondary contact: Joseph Tomoleoni, 831-254-9750, jtomoleoni@usgs.gov

3. Disqualification factor. A conviction, or entry of a plea of guilty or nolo contendere, for a felony violation of the Lacey Act, the Migratory Bird Treaty Act, or the Bald and Golden Eagle Protection Act disqualifies any such person from receiving or exercising the privileges of a permit, unless such disqualification has been expressly waived by the Service Director in response to a written petition. (50 CFR 13.21(c)) Have you or any of the owners of the business, if applying as a business, been convicted, or entered a plea of guilty or nolo contendere, forfeited collateral, or are currently under charges for any violations of the laws mentioned above?

   ☒ No ☐ Yes

   If you answered "Yes" to Question 3, provide: a) the individual's name; b) date of charge; c) charge(s); d) location of incident; e) court; and f) action taken for each violation. Please be aware that a "Yes" response does not automatically disqualify you from getting a permit.

4. List the scientific name (genus, species, and, if applicable, subspecies), and common name of each species for which you are applying.

   Enhydra lutris nereis, Southern sea otter

5. Provide a copy of any other applicable Federal, local, or state permissions (e.g., National Wildlife Refuge Special Use Permit, NOAA National Marine Sanctuary permit, etc.) required to conduct your proposed work, OR indicate whether you have applied for, secured, or will apply for such permissions (please provide contact information).

6. Is/are the species or population stock(s) for which you applying listed under the U.S. Endangered Species Act (ESA), a species proposed for listing, or a candidate species?

   ☐ NO ■ YES; complete a-d, below.

   a. Attach a justification for taking an ESA-listed species, and explain why your proposed activities are not appropriate for a similar non-ESA-listed species;

   b. Describe both the short- and long-term anticipated effects of each of your activities alone or cumulatively on the behavior and physiology of the target animals and critical habitat or proposed critical habitat for the species.

c. Describe how the animals will react to your actions and the consequences of those reactions.

see attached pages

d. Identify how you would mitigate any potential negative effects.

see attached pages

7. Do you plan to conduct activities with **MARINE MAMMALS IN THEIR NATURAL ENVIRONMENT** (i.e., in the wild) where "non-target" marine mammal and ESA-listed species occur in the United States? ("Non-target" species are species that are not the subject of your activities.)

☐ NO ☒ YES; We will need to assess impacts to marine mammal and ESA-listed species that are not the subject of your activities; therefore, provide responses to a-c, below:

a. A list of all non-target marine mammals and ESA-listed species that might occur in your project area or might be affected by your activities;

see attached

b. The maximum number of animals of each non-target marine mammal and ESA-listed species (# per species) that might be harassed by your activities, the precautions that you will take to minimize the likelihood that harassment will occur, and the actions that you will take should harassment occur; and

see attached

c. The maximum number of animals of each non-target marine mammal and ESA-listed species (# per species) that might be taken (e.g., killed, injured, feeding activities disrupted, etc.) by your activities, your precautions to minimize the likelihood that take will occur, and your actions should take occur.

We do not expect any non-target marine mammals or ESA-listed species to be taken as a result of our activities.

(Note: The following link provides access to resources that might be useful to you in gathering the required information to answer this question, including links to FWS and NMFS offices responsible for managing marine mammals stocks, and Stock Assessment Reports, which provide population status information on marine mammal stocks.

8. Do you plan to conduct your public display, research, or MMPA enhancement activities with **MARINE MAMMALS that are CURRENTLY HELD IN A CAPTIVE ENVIRONMENT (including, but not limited to import into the U.S. of captive-held live animals/specimens)**

☐ NO ☐ YES; specify the number of captive individuals for each species of interest: _____and for each individual animal of each species of interest, respond to a-g, h and i below.

Note: You may provide the information in tabular form, as in the example below:

a. Species	b. Sex	c. Birth date	d. Description (e.g., ID #, ISIS #, transponder #, tattoo #)	e. Country of origin	f. Source (i.e., wild, captive-born, or captive-bred)	g. Current location of animal
Example: *Enhydra lutris kenyoni*	Female	Approx. 04/09/2010	House # XXX123 Transponder # 45678	USA	wild	ABC Aquarium, Anchorage Alaska

h. For **captive-born or captive-bred animal(s)**, provide a breeder's statement, ARKS/ZIMS specimen report, or other information that documents the animal was born in captivity, location of birth, and information on the source of the parental stock (e.g., captive-born, wild).

i. For **captive-held animal(s) already taken from the wild**, provide:
   i. Information (e.g., ARKS/ZIMS specimen report(s)) on the source of the animal, including when the animal was removed from the wild, by whom, and the location.
   ii. A copy of the MMPA permit or LOA under which the animal is currently being held in captivity or a copy of the MMPA permit or authorization authorizing removal of the animal from the wild.
   iii. Has the U.S Fish and Wildlife Service deemed the animal(s) non-releasable to the wild?

☐ **YES**; provide a copy of the official letter confirming the animal's non-releasable status.

☐ **NO**; if you are requesting to have the animal(s) deemed non-releasable at this time, provide an explanation of the following: a) why release of the animal to the wild will not likely be successful given its physical condition; b) why release of the animal to the wild will not likely be successful given its behavior including adverse interactions with humans or marine mammals; **or** c) why release of the animal to the wild may jeopardize the wild population of the species.

9. For animal(s) to be taken from the wild and brought into a captive environment for public display, research, or MMPA enhancement activities, provide for each species:

   a. Information on the actual or proposed date(s) and location(s) of collection;
   b. The numbers of animals of each age class and sex to be taken from the wild (include a definition of each of these age classes by range of # months and/or years).
   c. An estimate of the species' population stock in the wild; Note: stock assessment reports might assist you with this information and are available at the following FWS field offices, depending on the species involved:

      Southern sea otter: Ventura Fish and Wildlife Office

      Northern sea otter: Washington Fish and Wildlife Office

      Northern sea otter, walrus, polar bear: Marine Mammals Management, AK

      Manatee: North Florida Ecological Service Office

   d. A description of the efforts made to acquire captive-held animals, in lieu of taking animals from the wild.

(Note: for holding and maintaining animals you must also provide the information requested in question 14.)

10. Are you requesting to **CAPTURE LIVE** marine mammals in the wild? (i.e., for research, public display, or MMPA enhancement)

☐ NO ☒ YES; specify the number of individuals to be captured for each species of interest: 606 left over from existing permi
and provide a – i, below:

a. A description of the manner in which the animal will be captured, type of gear used, and deployment method (e.g., from shore or boat approach and net deployment).
b. Methods of restraint and holding, including dimensions/type of holding container, if used;
c. The holding time required prior to transport or release of the animal;
d. Number and roles of personnel participating in the captures;
e. Duration of restraint/holding from capture to release; and
f. The number of non-target individual animals of the target species that will be incidentally harassed during capture activities, and precautions you will take to minimize incidental harassment of non-target animals;
g. If capturing females with calves/pups/cubs, describe:
   i. How calves/pup/cubs will be held;
   ii. Which procedures will be conducted on them;
   iii. The duration of time the pair will be separated; and
   iv. Procedures used to reunite the pair, and if they do not reunite, explain the disposition of the calf/pup/cub.
h. A description of the use of drugs during capture, including:
   i. Name of each drug/chemical used, its dosage rate (ml/kg), method of administration (IV, IM, SQ, topical and whether remotely-deployed IM), and purpose of the drug;
   ii. Duration of drug and required holding time;
   iii. The names of the personnel who would administer the drugs;
   iv. Provisions to minimize adverse reaction(s), including the use of appropriate drug reversals;
   v. Procedures to be used to minimize the chance that drugged animals will escape or enter the water prior to complete immobilization; and
   vi. Measures to be taken to ensure that the animal is fully recovered prior to release.
i. What emergency procedures would be employed (e.g., drugs, bagging, CPR, etc.) in the event that an animal's condition starts deteriorating during capture activities?

11. Are you requesting to **IMPORT LIVE** marine mammals?

☒ NO ☐ YES; specify the number of individuals to be imported for each species of interest: ____________
and provide a – m, below:

a. The proposed date of import;
b. The name and address of the foreign exporter, including the country of export;
c. For wild-sourced animal(s), a description of the manner in which it was taken from the wild and a copy of the foreign collecting/capture authorization(s);
d. The age (approximate or known) of the animal at the time of removal from wild or from its mother;
e. The age (approximate or known) of the animal at time of weaning; and
f. For females, respond to i & ii, below:
   i. At the time of removal from the wild, was the female pregnant? ☐ NO ☐ YES
   ii. At the time of the proposed import, will the female be pregnant? ☐ NO ☐ YES
g. A description of the means and duration of the transportation used to move and import the animals;
h. A description of the type, size, and construction of all shipping containers used to transport the animals;
i. A description of the arrangements for watering or otherwise caring for the animals during transport;
j. A description of the qualifications of each person accompanying the animal that demonstrates their ability to address the animal's needs during transport;
k. A copy of the transport plan;

l. Quarantine plans, including location and time-frame; and
m. Any additional documentation showing compliance with U.S. Department of Agriculture (USDA) regulations for transport and care of live marine mammals (7 U.S.C. 2131-2159; 9 CFR 3, Part E).

NOTE: A separate CITES permit will be required from our office prior to the import of live <u>CITES Appendix I species</u>.

12. Are you requesting to **IMPORT PARTS/SPECIMENS** of/from marine mammals?

■ NO ☐ YES; provide a – m, below:

a. The proposed date of import;
b. The name and address of the foreign exporter, including the country of export;
c. The current location of the specimens;
d. The country of origin of the animals from which the specimens were/will be collected;
e. List the number of animals by species, age class/life stage, and sex from which parts/samples are sought. If you are requesting opportunistic sample import, you may request an unlimited number of samples from a specified number of animals, by taxa (e.g., unlimited samples from up to 100 polar bears annually).
f. The types of specimens to be imported (e.g., blood, skin biopsy, carcasses, etc.) and number of each type from each animal;
g. The source of the specimens to be imported (wild, captive-bred, or captive born);
h. Were the animals/will the animals be alive or dead at the time of sample collection?

☐ DEAD ☐ LIVE

i. Provide a detailed description of the source of the specimens to be imported and the manner in which the sample was/will be taken or collected. For example, this might include the following sources:
   i. Animals in captivity (samples taken during routine husbandry procedures or under separate authorization; distinguish between permanently captive in public display or research facility or temporarily captive in rehabilitation facility);
   ii. Animals in foreign countries stranded alive or dead or that died during rehabilitation;
   iii. Animals killed during legal subsistence harvests;
   iv. Animals killed incidental to legal commercial fishing operations;
   v. Samples from other authorized researchers or collections;
   vi. Soft or hard parts that are sloughed, excreted, or discharged naturally.
j. Provide a copy of the foreign collecting/capture authorization(s) (if not required, indicate "not required");
k. If importing samples from subsistence-hunted marine mammals in foreign countries, describe the subsistence method. Include documentation, if available, that verifies that the taking was/will be conducted in a humane manner (i.e., using the method that involves the least possible degree of pain and suffering);
l. If importing samples from live animals, describe how the samples were/will be collected, including animal handling and sample collection protocols. This should include a description of how the take was humane; and
m. Describe how the specimens will be preserved, shipped, and stored/curated.

NOTE: A separate CITES permit will be required from our office prior to the import of specimens of <u>CITES Appendix I species</u>.

13. Are you requesting to **EXPORT or RE-EXPORT PARTS/SPECIMENS** of/from marine mammals?

■ NO ☐ YES; provide a – e, below:

a. The types of specimens and quantity of each to be exported/re-exported;
b. The complete name and address of person/facility receiving the specimen(s);
c. A description of the origin of the specimens to be exported/re-exported;
d. The name(s) of the facility/institution that currently holds the specimens; and
e. Whether a portion of the specimen will need to be re-imported following export/re-export.

NOTE: A separate CITES permit will be required from our office prior to the export/re-export)

14. Are you a facility requesting **MAINTENANCE of LIVE ANIMALS** (i.e., holding and caring for animals) for public display, research or MMPA enhancement activities?

    ■ NO ☐ YES; specify the number of individuals to be held for each species of interest: ________________;

    and provide a – h, below:

    a. A complete description, including photographs and/or diagrams (no blueprints), of the area and facilities where the animals will be held (including the dimensions of pools and haul-out areas);
    b. The number of animals of the same species (include age and sex) presently maintained at the facilities and information indicating whether there is space for additional animals without exceeding USDA/Animal and Plant Health Inspection Service (APHIS) limits (i.e., provide the maximum # of animals of each species that could be held).
    c. A list of all animal caretakers and a description of their specific duties/responsibilities;
    d. A description of the animal caretakers' experience in the care, handling, and maintenance of the marine mammal species that is/are the subject of this application and copies of curriculum vitae (CVs) that demonstrate such experience for each caretaker;
    e. A description of specific State requirements regarding who (e.g., attending veterinarians, vet technicians, researchers) may handle and administer certain drugs;
    f. A list of all marine mammals under the jurisdiction of FWS maintained at the facility (specify whether they are held in the same exhibit/holding area as the target animals will be held and maintained);
    g. A description of all deaths of FWS-jurisdiction marine mammal species at the facility within the past five years and the steps taken to prevent or decrease similar mortalities;
    h. A copy of the facility's USDA/APHIS, Animal Welfare Act (AWA) license and the most recent APHIS inspection report.

15. If you are a facility requesting maintenance of live animals for which the primary purpose is scientific research, or enhancement of survival or recovery of the species, are you seeking approval to publicly display the subject animals?

    ■ NO ☐ YES; in a-c, below, provide information to show that:

    a. The facility is open to the general public without limitations or restrictions (other than by the charging of an admission fee);
    b. The facility offers a program for education or conservation purposes that is based on professionally recognized standards of the public display community; and
    c. Such display will not interfere with attainment of the objectives of the permitted/authorized activity.

PART II.

FOR PUBLIC DISPLAY

16. For U.S. facilities, provide information to show that the facility:
    a. Is open to the general public without limitations or restrictions (other than by the charging of an admission fee);
    b. Offers a program for education or conservation purposes that is based on professionally recognized standards of the public display community (include copies of outreach/educational materials and photos of signage); and
    c. Is registered or holds a license issued by the USDA Animal and Plant Health Inspection Service (APHIS) under the Animal Welfare Act (AWA).

PART III.

FOR SCIENTIFIC RESEARCH

17. Explain how the proposed research meets the MMPA definition of "bona fide research," i.e., scientific research on marine mammals, the results of which: (A) are likely to be accepted for publication in a referenced scientific journal; (B) are likely to contribute to the basic knowledge of marine mammal biology or ecology; or (C) are likely to identify, evaluate, or resolve conservation problems.

    see attached.

18. Provide a detailed description of the proposed project. You may attach a formal research proposal, provided it includes all the requested information, including:

    a. Objectives and hypotheses and associated methodology;

    b. Background information discussing relevant published literature on the subject of your proposal, with citations;

    c. An explanation of how this study is different from, builds upon, or duplicates past research;

    d. An explanation of how you determined your sample size/take numbers (e.g., based on previous encounter rates or abundance estimates for the study area). If appropriate for your study, include a power analysis or other sample size estimation to show whether the sample size is sufficient to provide statistically significant or otherwise robust results appropriate for your study;

    e. If proposing novel procedures, include a discussion on results from pilot studies or studies on other species, if available; and

    f. Disposition of animals or remaining specimen material once your project is complete.

19. Provide the expected research schedule (clearly specify the proposed start date and end date of your research or field season(s) and overall duration of the project). Include the months of the year and frequency of fieldwork/sampling (e.g., number of times per year). If your research extends beyond five years, or is a continuation of previously authorized research, give information about when the research began and when you expect it to end.

Level A harassment means any act of pursuit, torment, or annoyance, which has the potential to injure a marine mammal or marine mammal stock in the wild.

Level B harassment means any act of pursuit, torment, or annoyance, which has the potential to disturb a marine mammal or marine mammal stock in the wild by causing disruption of behavioral patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering.

Take, as defined by the MMPA means to harass, hunt, capture, or kill, or attempt to harass, hunt, capture, or kill any marine mammal.

20. Indicate which research procedures/activities you will be conducting that will or might result in **TAKE or HARASSMENT of TARGET species**, and describe each activity in detail, including the information indicated in a-i, below.

a. Administration of drugs (including emergency drugs and prophylactic antibiotic use) or other substances (e.g., stable isotopes); include i-vii, below, in your activity description:

i. Name of each drug/chemical used, its dosage rate (ml/kg), method of administration (IV, IM, SQ, topical and whether remotely-deployed IM), and purpose of the drug;
ii. Duration of drug and required holding time;
iii. The names of the personnel who would administer the drugs;
iv. A description of specific State requirements regarding who (e.g., attending veterinarians, vet technicians, researchers) may handle and administer certain drugs;
v. Provisions to minimize adverse reaction(s), including the use of appropriate drug reversals;
vi. Procedures to be used to minimize the chance that drugged animals will escape prior to complete immobilization; and
vii. Measures to be taken to ensure that the animal is fully recovered prior to release.

b. Aerial and vessel surveys (manned); include i-v, below, in your activity description:

i. Type of survey craft and vessel;
ii. Type of survey (e.g., line transect, photogrammetry);
iii. Number of surveys per year;
iv. Minimum and maximum altitude/approach distance; and
v. Duration spent with group or individual per day.

c. Aerial surveys using unmanned aircraft systems (UAS); include i-xii, below, in your activity description:

i. Dimensions, mass, and battery life of UAS;
ii. Will the UAS ever be beyond the line of sight?
iii. Does the device have an auto-return feature should the device fail?
iv. Ground control station description (what it is, where it will be located, e.g., on shore or on vessel, number of stations, and how close the station will be to animals);
v. Spotter roles (e.g., one spotter monitoring the UAS, another for monitoring the ground control station);
vi. Do you have the appropriate FAA permits/authorizations (including pilot licenses)?
vii. Type of survey (e.g., line transect, photogrammetry);
viii. Number of surveys per year;
ix. Minimum and maximum altitude/approach distance;
x. Duration spent with group or individual per day;
xi. The names of the personnel who will pilot the aircraft, and
xii. Mitigation measures you will use to minimize disturbance including specific measures you will use to avoid separating female-calf/pup/cub pairs, and measures to ensure the UAS will not collide or crash into any of the animals.

d. Capture and restraint; if you will be capturing animals, ensure that you have completed question 10, above.

e. Instrumentation, Marking, and Tagging (MTI); include i-x, below, in your activity description:

i. The type of MTI (including dimensions and mass);
ii. The maximum number and total mass of MTIs to be attached to/implanted in an animal at a given time;
iii. The maximum dart penetration depth if MTI is attached via darts;
iv. Methods and location of attachment, including minimum approach distance for remote MTI attachment;
v. If surgeries for implantable tags are being conducted, specify who will be conducting them, where (in the field or in a facility), and if antibiotic prophylactics will be administered;
vi. The maximum number of times an animal would be fitted with MTIs in a given year;
vii. Will recapture be necessary (if so, how many times will animals be captured annually), would the instrument/tag have a release mechanism, or would the instrument/tag fall off?

viii. Have the proposed MTIs been used previously on this species?
ix. What are the potential adverse effects and the means of monitoring new MTIs for adverse effects?
x. What actions will be taken in the event that the MTI has a significant adverse impact on the animal(s), and what is the method of animal release from the MTI?

f. Intrusive sampling (e.g., blood, blubber, muscle, skin); include i-xiii below, in your activity description:
i. Will sampling be remote or under restraint?
ii. Will local anesthetics be administered?
iii. Type of tissues sampled;
iv. Size or volume of sample (diameter and depth or total volume);
v. Target sampling location on body;
vi. Maximum number of samples per animal per day and per year;
vii. Sampling intervals (e.g., for serial blood or biopsy samples);
viii. Collection method and equipment/materials used (e.g., dart fired from rifle, dart depth, sterilization/disinfection);
ix. If remote, what is the minimum approach distance?
x. If restrained, describe treatment of site of sample collection (e.g., cleansing, wound left open or closed);
xi. Number of attempts per animal per day (include total number of attempts needed for all work if requesting multiple procedures (e.g., remote tagging and biopsy) on same animal on the same day);
xii. The names of the personnel who will conduct the sampling; and
xiii. Sample preservation and analysis.

g. Non-intrusive sampling (e.g., behavioral observations via focal follows and ground surveys, scat collection, passive acoustic monitoring and recording, photo-ID, photogrammetry, remote video monitoring, underwater photography); include i-vi, below, in your activity description:
i. Approach, sampling methods, and platform type;
ii. Minimum and maximum approach distance (specify different distances for each deployment method);
iii. Are researchers within sight of animals or not (e.g., from a blind)?
iv. Frequency of observations/sampling;
v. Duration of observations/sampling per day; and
vi. If conducting underwater photography/videography, specify the method (e.g., snorkeling, underwater pole cam, or divers using typical gear or rebreathers) and number of people in the water at a given time, including the safety diver/snorkeler.

h. Testing methodologies on captive-held animals; include i-iii, below, in your activity description:
i. A description of the methodologies and equipment to be used;
ii. Duration and times of testing and data analyses; and
iii. Methods used to decondition the animals that will be released to the wild after testing.

i. Other procedures/activities; list each additional procedure/activity and provide a detailed description of each, including all appropriate mitigation measures (note, we might contact you with follow-up clarification of methodologies), novel procedures, and any procedures involving active acoustic or hearing studies).

21. **For each procedure/activity**, provide the information in a-j, below, including the maximum number of animals of each species expected to be taken by the procedure annually, broken down by sex and age class; the number of takes per animal per year; and an estimate of the number of animals of the study species that might be incidentally harassed (i.e.,# of non-target animals of your study species that might be harassed by your activities). Also, include the time-periods and specific locations of the takes. This information may be provided in table format such as:

a. Species	b. Procedure/ Activity	c.Level A or Level B Harassment*or other Take**	d.Age Class(see question 23, below)	e. Sex	f.Max. # Animals Per Year	g.Max. # Takes Per Animal Per Year	h.Max. # non-target conspecifics incidentally harassed	i.Time-period	j. Location

* **Level A harassment** means any act of pursuit, torment, or annoyance which has the potential to injure a marine mammal or marine mammal stock in the wild. **Level B harassment** means any act of pursuit, torment, or annoyance which has the potential to disturb a marine mammal or marine mammal stock in the wild by causing disruption of behavioral patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering.

****Take**, as defined by the MMPA means to harass, hunt, capture, or kill, or attempt to harass, hunt, capture, or kill any marine mammal.

22. Will any female-pup/calf/cub pairs be targeted for any of the proposed research activities? If so, describe how you would minimize impacts on pups/calves/cubs and associated females during each of those activities.

23. Define each age class listed in your response to question 21(d), above, for each species (i.e., list the range of months or years (or mass for otters) constituting each age class); provide the minimum age (or mass) that animals will be targeted for take activities; and indicate whether females with calves/pups/cubs less than that minimum age will be targeted for take activities?

24. Describe the precautions that will be taken to minimize the likelihood that harassment of non-target individuals of the study species will occur and the actions that will be taken should harassment occur.

25. Explain how you determined that your methods involve the least possible degree of pain and suffering and why there are no feasible alternative methods to obtain the desired data or results.

26. Provide: a) an estimate of the possible number of unintentional deaths or serious injuries that might result from your research activities; b) the number of unintentional and intentional (via euthanasia for humane purposes if an animal is seriously injured) deaths or serious injuries you seek approval for annually; c) the steps you will take to reduce the likelihood of deaths or injuries; and d) if euthanasia might occur, provide the method of euthanasia (e.g., gunshot, drug, etc.) and who would conduct the euthanasia procedure.

27. In the event of a death, will a necropsy be conducted on the animal?
☐ NO ☒ YES

28. If a female animal accompanied by calf/pup/cub(s) dies during research activities, specify the disposition of the associated calf/pup/cub(s).

29. If biological samples are to be collected or received domestically, provide responses to a through j, below, for each individual animal per species. This information, or part of the information, may be provided in table format such as the table below. (Note: if your only proposed activity is to transfer dead marine mammal specimens for purposes of public display or scientific research, complete application Form 3-200-87).

a. Species	b. ID #	c. Sex	d. Source (Wild or Captive/ Live or Dead)	e. Birth Date or age class	f. Type of Samples (blood, tissue, DNA)	g. Number of animals sampled annually	h. Number of times each animal will be sampled annually	i. Packaging and Preservation of samples	j. Use/ Disposition of Samples

k. Provide a detailed description of the source of the specimens, including the circumstances under which the animals were/will be taken. For example, this might include the following sources:
   i. Animals stranded alive or dead;
   ii. Animals killed during legal subsistence harvests;
   iii. Animals killed incidental to legal commercial fishing operations;
   iv. Samples from other authorized researchers or collections;
   v. Soft or hard parts that are sloughed, excreted, or discharged naturally;
   vi. Samples that will be/were intrusively collected from captive-held animals;
   vii. Samples that will /were collected from wild animals.

l. If collecting samples from live animals, describe how the samples were/will be collected, including animal handling and sample collection protocols.

m. For samples received domestically from U.S. permitted researchers, include the researcher's name, affiliation, and permit number under which samples will be/were collected.

(Note: if samples are to be imported, you must answer question 12, above).

30. Provide a list of all personnel that will be involved in the project, identifying each as either a principal investigator or co-investigator, their project duties/responsibilities, and a brief description or CV that demonstrates their experience and expertise to perform their designated duties, including knowledge of the marine mammal species that is/are the subject of this application.

31. Describe how you will collaborate or coordinate with other researchers in your study area. Who are they? Explain how this will occur and how it will minimize negative impacts on the species. For example, will it involve sharing resources, samples or data; timing surveys to minimize disturbance, etc.?

32. If you intend to conduct research on animals in a captive-holding facility such as a zoo or aquarium, provide documentation showing that the facility(ies) has authorized you to conduct your proposed activities.

33. Animal Welfare Act (AWA) Compliance (for research on live animals only): AWA requirements apply to all research facilities, which include institutions, organizations, or people that use or intend to use LIVE animals in research, tests, or experiments; AND, that receive funds under a grant, award, loan, or contract from a department, agency, or instrumentality of the U.S. for the purpose of carrying out research, tests, or experiments, or acquires or transports the animals in commerce. **Provide the following documentation:**

    a. Registration under the AWA as a research facility:
        i. Attach a copy of your APHIS certificate of registration as a research facility, or for Federal facilities, a letter from your Institutional Officer that you are compliant with applicable requirements for scientific research under the AWA; **OR**
        ii. If your facility does/will not conduct activities requiring registration under the AWA, attach a letter from APHIS confirming that registration is not required.
    b. Institutional Animal Care and Use Committee (IACUC) documentation: If your facility is registered as a research facility under the AWA or is a Federal research facility (see a.i), attach the applicable IACUC documentation from the list in i-iii, below. Please note that all activities that involve an invasive procedure, harm, or materially alter the behavior of an animal under study, even if the activities are carried out in the field, are subject to IACUC review and approval. See (AWA regulations and standards for definition/explanation of covered research activities.):
        i. Attach a copy of your final protocols with the IACUC signed approval; **OR**
        ii. Attach a copy of your proposed protocols to be reviewed by your IACUC along with an explanation as to how and when the protocols will be reviewed (Note: A copy of your final signed protocols and certification will be required prior to permit issuance.); **OR**
        iii. Attach the IACUC determination that your research activities are not subject to IACUC review and approval.
    c. If your facility is not registered as a research facility under the AWA, please provide an explanation of how your take activities are reviewed and monitored to assure that the proposed takes are humane (i.e., using the method that involves the least possible degree of pain and suffering).

PART IV.

FOR RESCUE, REHABILITATION, AND/OR RELEASE OF STRANDED[2] MARINE MAMMALS (☑ CHECK IF NOT APPLICABLE)

Marine mammals may be captured from the wild by duly authorized U.S. Fish and Wildlife Service personnel or **authorized cooperators** for the protection or welfare of the marine mammal or for the protection of public health and welfare and held at cooperating authorized facilities. This section of the application is for those parties interested in applying for a letter of authorization (LOA) under MMPA Sections 109(h)/112(c). Parties interested in rescue, rehabilitation, and release activities involving ESA-listed marine mammals would also use this section of the application to apply for an accompanying ESA permit for enhancement of propagation or survival of the species OR to apply as a "sub-permittee" working under the authority of an ESA permit held by different organization or agency. Authorized "sub-permittees" would be responsible for coordinating their activities with the designated ESA permit-holder (i.e., "Permittee") and would be required to comply with the conditions of that permit. Each authorized party's MMPA LOA will document the ESA permit number associated with that LOA, whether the party is a sub-permittee or the Permittee on the ESA permit.

The MMPA LOA or, for ESA-listed species, the combined MMPA LOA and ESA permit would provide authorization for individuals or institutions to work as "cooperators" for the purpose(s) of rescue, rehabilitation, and/or release of stranded marine mammals. Marine mammal rescues are dangerous activities that require trained staff, specialized equipment, and clear communication among stranding partners. The U.S. Fish and Wildlife Service provides opportunities for different levels of involvement for approved cooperators: verifiers, rescuers, transporters, critical care facilities, and rehabilitation/holding facilities. These roles are defined in question 37, below.

34. Are you/your organization currently conducting research activities with marine mammals?

☐ NO ☐ **YES; provide the permit number under which you are conducting research____________.**

35. What type of authorization are you requesting (check all that apply)?

☐ LOA under MMPA Sections 109(h)/112(c)

☐ ESA permit for enhancement of propagation or survival of the species

☐ Sub-permittee under ESA permit #_________________.

36. What type of stranding event are you requesting to respond as a cooperator for a U.S. Fish and Wildlife Service marine mammal rescue, rehabilitation, and release program?

☐ OIL SPILL EVENTS

☐ OTHER CONTAMINANT SPILL EVENTS; SPECIFY TYPES______________________________.

☐ OTHER STRANDING EVENTS

[2] The term, "stranding," as defined by the MMPA means an event in the wild in which: (A) a marine mammal is dead and is on a beach or shore of the United States or in the waters under the jurisdiction of the United States (including any navigable waters); OR (B) a marine mammal is alive and is on a beach or shore of the United States and unable to return to the water, on a beach or shore of the United States and, although able to return to the water, is in need of apparent medical attention, or in the waters under the jurisdiction of the United States (including any navigable waters), but is unable to return to its natural habitat under its own power or without assistance.

37. Indicate at which level(s) of responsibility the cooperator will participate (Check all that apply, and respond to the questions below).

☐ **VERIFIER:** The role of verifiers is limited to answering requests to provide physical verification of the condition of reported live, distressed animals and communicating the location and status of an animal to the appropriate person(s), including the rescue program coordinator and, if so directed, the nearest approved rescue facility. In most cases verifiers are required to stay with the animal until an approved rescue and transport team arrives. No physical interaction with animals is authorized under this designation. Verifiers may handle animals only under the guidance of an onsite designated rescue team(s).

a. Describe your organization's experience in verifying the condition of reported live, distressed or injured animals of each species requested (e.g., years of experience, number of responses, etc.).

b. Describe the qualifications of each of your staff who would be serving as a verifier in your organization that demonstrates their ability to verify the condition of reported, live, distressed animals of each species requested (including any work and/or volunteer experience that describes where, with what authorized organization, approximate number of hours, approximate number of verifications, and other relevant experience). Resumes, curriculum vitae (CV), and other supporting documents may be used to describe qualifications, including experience with the marine mammal species (or another similar marine mammal species) that is/are the subject of this application.

c. List and describe any specialized training that your staff have completed to perform this duty, including where and when the training occurred, which organization provided the training, types of training, and other relevant information.

d. Describe numbers and types of:

a) vehicles (cars, trucks, boats, etc.) that will be used to travel to/from locations of reported, live, distressed animals;

b) communications devices that will be used to communicate with rescue responders (phones, radios, etc.); and;

c) any other related equipment.

e. Provide a statement that you will be available to respond to reports of live, distressed animals of the subject species when needed.

☐ **RESCUER**: Rescuers respond to reports of injured and/or distressed animals and can initiate hands-on rescue and transport efforts as needed. This level of involvement requires substantial expertise and training in species-specific rescue techniques. Rescuers must meet U.S Department of Agriculture (USDA) standards for Humane Handling, Care, Treatment, and Transportation of Marine Mammals when rescuing live animals.

a. Describe your organization's experience in rescuing distressed or injured animals of each species requested (e.g., years of experience, number of rescues, etc.).

b. Describe the qualifications of each of your staff who would be serving as a rescuer in your organization that demonstrates their ability to rescue distressed animals of the subject species (including any work and/or volunteer experience that describes where, with what authorized organization, approximate number of hours, approximate number of rescues, and other relevant experience). Resumes, CVs, and other supporting documents may be used to describe qualifications, including experience with the marine mammal species (or another similar marine mammal species) that is/are the subject of this application.

c. List and describe any specialized training that your staff have completed to perform this duty, including where and when the training occurred, which organization provided the training, types of training, and other relevant information.

d. Describe how you meet or exceed USDA standards. Include a description of the number and types of:
   i. vehicles (cars, trucks, boats, etc.) that will be used to support the rescue of distressed animals;
   ii. rescue equipment (nets, stretchers, etc.) that will be used for rescues;
   iii. communications devices that will be used during rescues (phones, radios, etc.); and
   iv. any other related equipment.

e. Describe your methods of capture of the species of interest, including:
   i. Methods of restraint and holding, including dimensions/type of holding container, if used;
   ii. Minimum number of personnel participating in captures at any given time;
   iii. Precautions you will take to avoid separating female-calf/pup/cub pairs, and protocol in the event they are separated, including disposition of the separated calf/pup/cub; and
   iv. Precautions you will take to minimize incidental harassment of non-target animals of the target species.

f. Provide a statement that you will be available to respond to reports of live, distressed animals when needed.

☐ **TRANSPORTER:** Transporters respond to reports of injured and/or distressed animals and initiate transport

efforts as directed. This level of involvement requires substantial expertise and training in the species-specific transport methodology, as well as, the necessary equipment and trained staff to accompany and move the animals to or between approved critical care and/or rehabilitation/holding facilities. Transporters must meet U.S Department of Agriculture (USDA) standards for Humane Handling, Care, Treatment, and Transportation of Marine Mammals when transporting live animals. Transports must also be consistent with Animal Welfare Act requirements for transportation and USFWS transport regulations.

a. Describe your organization's experience in transporting animals of each species requested (e.g., years of experience, number of transports, etc.).

b. Describe the qualifications of each of your staff in your organization who would be accompanying animals during transport, demonstrating their ability to transport, accompany, and support animals of the subject species (including any work and/or volunteer experience that describes where, with what authorized organization, approximate number of hours, approximate number of transports, and other relevant experience). Resumes, CVs, and other supporting documents may be used to describe qualifications, including experience with the marine mammal species (or another similar marine mammal species) that is/are the subject of this application.

c. List and describe any specialized training that your staff have completed to perform this duty, including where and when the training occurred, which organization provided the training, types of training, and other relevant information.

d. Describe how you meet or exceed USDA standards:

   i. Include a description of the number and types of: a) vehicles (trucks, boats, airplanes, etc.) that you will use to transport animals of the subject species; shipping containers that will be used to transport the animals (including type, construction, dimensions, and weight); other equipment that will be used in the transport of the animals (foam pads, water sprayers, stretchers, etc.); communications devices that will be used during transports (phones, radios, etc.); and any other related equipment.

   ii. Describe how the subject animals will be cared for during transport, including the number of attending staff and a description of the arrangements for watering or otherwise caring for the animals during transport.

e. Provide a statement that you will be available to transport animals of the requested species when needed.

☐ **CRITICAL CARE FACILITY:** These facilities hold and medically treat sick and/or injured animals whose lives would be jeopardized if care were not provided. These facilities have the species-specific equipment, experience and credentials necessary to rescue, stabilize, rehabilitate and release animals. These facilities may also provide long-term care, as needed, for generally healthy animals awaiting release, or they may provide long-term care for those individuals designated as "non-releasable". Critical care facilities must meet or exceed USDA standards for Humane Handling, Care, Treatment, and Transportation of Marine Mammals when maintaining, treating, and holding live animals.

a. Describe your organization's experience in maintaining, holding, and caring for distressed or injured animals of each species requested (e.g., years of experience, number of animals held, etc.).

b. Describe the qualifications of each of the staff in your organization who would be caring for, handling, and maintaining animals of the subject species (including any work and/or volunteer experience that describes where, with what authorized organization, approximate number of hours, approximate number of animals, and other relevant experience). Resumes, CVs, and other supporting documents may be used to describe qualifications, including experience with the marine mammal species (or another similar marine mammal species) that is/are the subject of this application.

c. For authorization as a critical care facility, you must have a qualified, critical care veterinarian. Provide the name of the person assigned this role and describe his/her qualifications, including a CV or resume that demonstrates his/her ability to perform this role.

d. Describe how you meet or exceed USDA standards. Include a description of:
   i. critical care and holding areas, including descriptions of holding tanks and haul-out areas. The description should include photographs, drawings, and/or diagrams illustrating the area(s) and facility (or facilities) where animals of the subject species will be held. When describing holding tanks, include dimensions (tank length, width, depth, water volume); describe pumps and filtration systems in tanks (including type and capacity and other relevant information); describe lifting apparatus; describe water heaters (including degree to which tanks can be heated); describe water source and type (and ability to use freshwater, saltwater and/or both); and any other relevant features.
   ii. The maximum number of animals of the subject species that can be housed at your facility.
   iii. The current distribution and number of animals of the subject species by holding tank at your facility (include sex, age (if known), time in captivity, age/size class, calves/pups/cubs, etc.).
   iv. All deaths of the subject species at your facility within the past five years and the steps taken to prevent them.

e. Describe quarantine plans, including location and time-frame.

f. Provide a copy of i) your USDA Animal and Plant Health Inspection Service (APHIS) Animal Welfare Act (AWA) license; and ii) your most recent APHIS inspection report.

g. Provide a statement that you will be available to maintain, care for, and house animals of the subject species when needed, including round the clock veterinary care.

☐ **REHABILITATION/HOLDING FACILITY:** These facilities provide routine husbandry for generally healthy

animals that require a minimum of specialized treatments. These facilities may provide long-term care, as needed, for generally healthy animals awaiting release, or they may provide long-term care for those individuals designated as non-releasable. Holding facilities must meet USDA standards for Humane Handling, Care, Treatment, and Transportation of Marine Mammals when holding live animals.

a. Describe your organization's experience in maintaining and holding animals of each species requested (e.g., years of experience, number of animals held, etc.).

b. Describe the qualifications of each of the staff in your organization who would be caring for, handling, and maintaining animals of the subject species (including any work and/or volunteer experience that describes where, with what authorized organization, approximate number of hours, approximate number of animals, and other relevant experience). Resumes, CVs, and other supporting documents may be used to describe qualifications, including experience with the marine mammal species (or another similar marine mammal species) that is/are the subject of this application.

c. For authorization as a holding facility, you must have a qualified veterinarian. Provide the name of the person assigned this role and describe his/her qualifications, including a CV or resume that demonstrates his/her ability to perform this role.

d. Describe how you meet or exceed USDA standards. Include a description of:
   i. holding areas, including descriptions of holding tanks and haul-out areas. The description should include photographs, drawings, and/or diagrams illustrating the area(s) and facility (or facilities) where animals of the subject species will be held. When describing holding tanks, include dimensions (tank length, width, depth, water volume); describe pumps and filtration systems in tanks (including type and capacity and other relevant information); describe lifting apparatus; describe water heaters (including degree to which tanks can be heated); describe water source and type (and ability to use freshwater, saltwater and/or both); and any other relevant features.
   ii. The maximum number of animals of the subject species that can be housed at your facility.
   iii. The current distribution and number of animals of the subject species by holding tank at your facility (include sex, age (if known), time in captivity, age/size class, calves/pups/cubs, etc.).
   iv. All deaths of the subject species at your facility within the past five years and the steps taken to prevent them.

e. Describe your facility's quarantine plans, including location and time-frame;

f. Provide a copy of i) your USDA Animal and Plant Health Inspection Service (APHIS) Animal Welfare Act (AWA) license; and ii) your most recent APHIS inspection report.

g. Provide a statement that you will be available to maintain and house animals of the subject species when needed.

h. Are you seeking approval to display the animals while holding and maintaining them for rehabilitation purposes?

___**NO** ___**YES**; in i-iii, below, provide information to show that:

i. The facility is open to the general public without limitations or restrictions (other than by the charging of an admission fee);
ii. The facility offers a program for education or conservation purposes that is based on professionally recognized standards of the public display community; and
iii. Such display will not interfere with attainment of the objectives of the permitted/authorized activity.

PART V.

FOR MMPA ENHANCEMENT OF SURVIVAL OR RECOVERY OF A SPECIES OR STOCK

Note: This section of the application should not be completed unless you are specifically requesting MMPA Enhancement activities (e.g., this section is not intended for those parties requesting to conduct rescue, rehabilitation, and release activities for marine mammals).

38. Provide information to show that your proposed activities are likely to contribute significantly to maintaining or increasing the distribution or population numbers necessary to ensure the survival or recovery of the species or stock in the wild.

39. Provide information to show that your proposed activities are consistent with any conservation or recovery plan for the species or stock, or, if no plans are available, that the activity is consistent with the actions required to enhance the survival or recovery of the species or stock and that would be addressed in a conservation or recovery plan. For activities that involve captive maintenance of live animals:

a. Provide an explanation on the benefit of removing animals from the wild into captivity; and
b. Include a description of plans in place for returning animals and any offspring to the wild.

(Note: You must also provide the information requested in question 14, above.)

22. Will any female-pup/calf/cub pairs be targeted for any of the proposed research activities? If so, describe how you would minimize impacts on pups/calves/cubs and associated females during each of those activities.

Yes. This has already been addressed in Question 10, section h. The response is identical here.

23. Define each age class listed in your response to question 21(d), above, for each species (i.e., list the range of months or years (or mass for otters) constituting each age class); provide the minimum age (or mass) that animals will be targeted for take activities; and indicate whether females with calves/pups/cubs less than that minimum age will be targeted for take activities?

We listed "all" for age classes targeted in 21(d). This is because of the nature of our research. It is impossible to do a study looking at population-level effects concerning movement patterns, diet, and survival if you only target certain age classes. Furthermore, it is difficult to determine the age class of a sea otter until have you have captured an examined the otter. The most reliable estimator of age comes from a dental examine, which requires a captured and anesthetized sea otter. Still, when we discuss different age classes, we break them down as follows:

Dependent pup
- Very small (<3 weeks old)
- Small (3-10 weeks old)
- Large (>10 weeks old)

Juvenile: 6 months to 1 year old
Sub-adult: 1-3 years old
Adult: 3-10 years old
Aged (Old) Adult: 10+ years old

As mentioned in responses to 10(h), when possible very small pups are generally avoided when attempting to capture sea otters. Pups must weigh at least 11lbs to qualify for flipper tagging.

24. Describe the precautions that will be taken to minimize the likelihood that harassment of non-target individuals of the study species will occur and the actions that will be taken should harassment occur.

As previously described in the response to question 10(f), any incidental harassment is almost always due to the habit of sea otters resting in groups or rafts. When capturing target otters in a raft, nearby otters may be disturbed. We always try to minimize the disturbance or incidental harassment of non-target otters. The rebreather diver techniques described previously are the best way to minimize incidental harassment, because the divers remain undetected for the entire dive, until the moment of capture. Our captures are most successful when we are completely undetected, so minimizing incidental harassment is inherent to the success of our work. When possible, we avoid targeting an animal when it's in a very large group of otters. The odds of successful capture decrease when the target is resting in a large group. Sometimes this cannot be avoided, however, most capture attempts are on solo animals, animals in pairs, or otherwise small rafts.

25. Explain how you determined that your methods involve the least possible degree of pain and suffering and why there are no feasible alternative methods to obtain the desired data or results.

Because of the broad, comparative nature of our research, captive animals are not appropriate surrogates for behavior or habitat use studies of wild sea otters, nor will they allow assessment of the survival, reproductive success, health and body condition of their wild counterparts. The only way conduct the these types of studies is through the capture and marking of individual wild sea otters.In order to continue to study behavioral, life history, and physiological characteristics of the threatened

SECTION E.

If requesting renewal or amendment of your current permit, provide an update of any activity that has occurred under the permit since your last report.

Since our last annual report (which included all activities in calendar year 2017), we have captured and flipper tagged 5 female southern sea otters. Four of these were adult and one was a subadult. Two of these sea otters (1 adult and 1 subadult) received radio transmitters. All 5 animals were captured off the Monterey Peninsula in March 2018.

PART I

5. Provide a copy of any other applicable Federal, local, or state permissions (e.g., National Wildlife Refuge Special Use Permit, NOAA National Marine Sanctuary permit, etc.) required to conduct your proposed work, OR indicate whether you have applied for, secured, or will apply for such permissions (please provide contact information).

Not Applicable

6. Is/are the species or population stock(s) for which you applying listed under the U.S. Endangered Species Act (ESA), a species proposed for listing, or a candidate species?

Yes.

A. Attach a justification for taking an ESA-listed species, and explain why your proposed activities are not appropriate for a similar non-ESA-listed species;

The USGS is the agency responsible for research on sea otters, a DOI trust species. Sea otters are protected under the MMPA and in some areas of their range (including California) are listed as threatened under the ESA. The USGS sea otter research project was initially established in the 1970's, has been operating continuously since then (through changes in personnel and in agencies where the project has resided), and is the primary agency responsible for conducting sea otter research. For some controlled studies (e.g, laboratory research), mink or ferrets may be used as a surrogate species for sea otters; however, for studies of sea otter populations in the wild, there is no suitable surrogate.

b. Describe both the short- and long-term anticipated effects of each of your activities alone or cumulatively on the behavior and physiology of the target animals and critical habitat or proposed critical habitat for the species.

Based on the results of our past research, we are able to gain some insight into both physiological and behavioral effects of capture/sampling/tagging/surgery over the short and long term. As far as substantial physiological effects that may affect survival rates, our data suggest that these are not substantial enough so as to be measurable: this assertion is based on a number of published demographic analyses (Siniff and Ralls, 1991; Tinker et al 2006; Tinker et al 2008) that estimate survival rates from radio tagged animals, and then compare these vital rate estimates with independent estimates derived from the age structure of the death assemblage, as well as the expected vital rates given the observed rate of population growth. Based on these comparisons, it appears that the radio-tagged cohorts exhibit the same age/sex specific survival and reproductive rates as the population as a whole (or if there is a difference, it is too small to be measurable).

As far as more subtle behavioral and physiological impacts of our activities, we have two data sets that we can use to infer that there are indeed significant, though transient, effects: 1) observational data on time-activity budgets and foraging behavior, and 2) data from archival time-depth recorders on dive behavior and core body temperature. In both cases, the data suggest a range of individual responses: at one extreme, some animals return to a regular pattern of feeding activity and core body temperature ranges within 24 hours of the surgical implantation of instruments (Fig 1 A,B), while at the other extreme some animals may exhibit slightly reduced (or occasionally elevated) temperatures and reduced diving activity for 2-7days post-surgery (Fig 1 C,D). Most animals fall somewhere between these two extremes: for animals that do exhibit a prolonged recovery time, the short term effects include reduced activity, elevated temperature and likely some mass-loss due to reduced feeding. The longer term effects for such animals are more difficult to gauge: because these animals return to typical activity levels within 1-2 weeks, and (in the case of females) go on to successfully gestate and raise pups (M. Staedler, 2010, Master's Thesis, UCSC), we infer that any long term effects of our activities fall within the normal range of physiological challenges dealt with by wild sea otters. Examination of the surgical sites on study animals that die (for reasons unrelated to our activities, e.g. shark bite or disease infections) and undergo thorough necropsies suggest that the surgical wounds are entirely healed within 30 days of the surgical intervention (Dr. M. Miller, CDFW, Dr. M. Murray, MBA, pers. comm.). In a very small number of cases, there may be some entanglement of one or both of the implanted instruments within the omentum (a tissue layer within the abdominal cavity): this condition is very rarely life threatening to the animal, although it may in some cases affect the ability of the omentum to respond to other "problems" within the abdominal cavity, such as intestinal parasites that burrow through the intestinal wall. Such conditions are very infrequent, having been observed in only a handful of cases out of many hundreds of animals that have undergone this procedure.

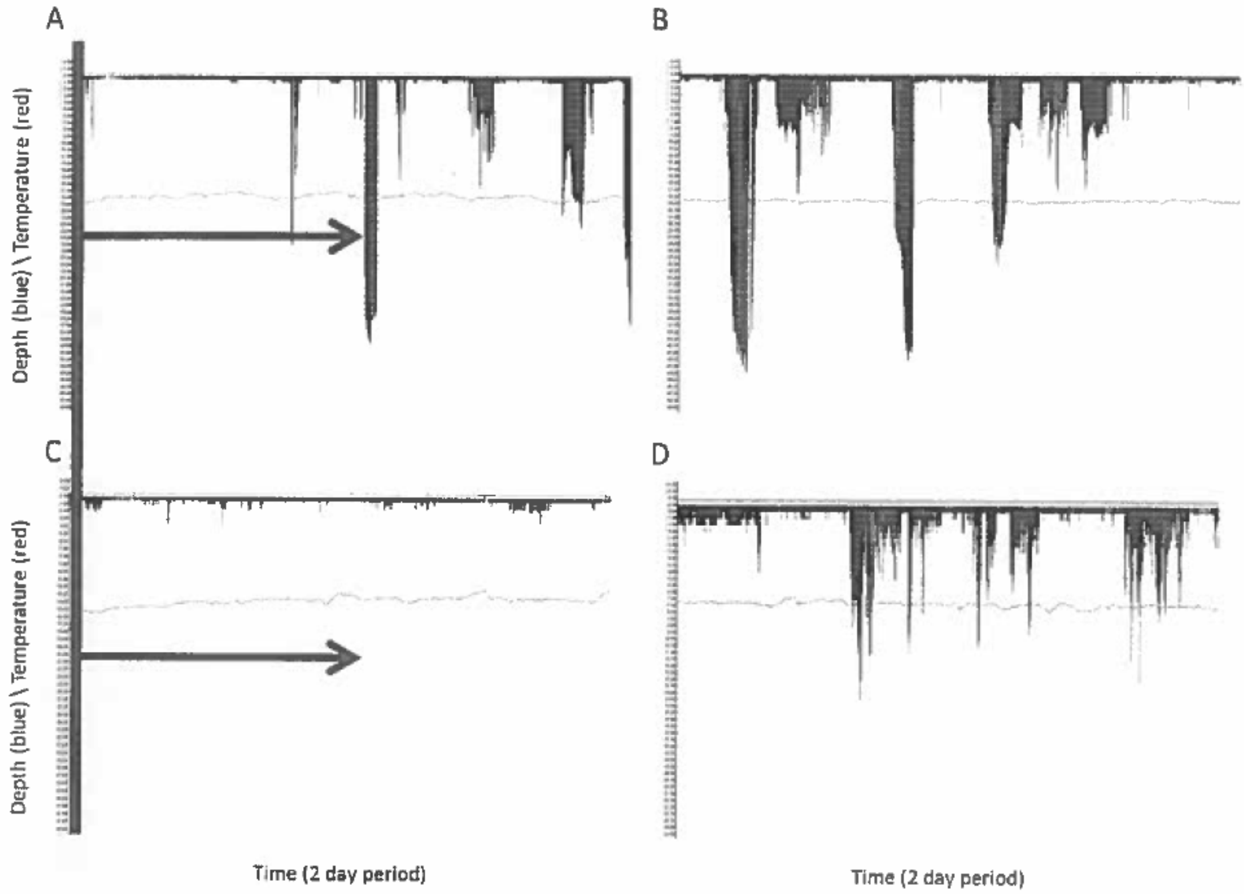


Figure 1. *Time-depth-temperature profiles from two adult female sea otters captured in Monterey. In all 4 plots, dive profiles are shown in blue (vertical depth axis scale is held constant, with surface at top and 45m depth at bottom), temperature profiles are shown in red (vertical temperature axis scale is held constant), and the horizontal axis is time (48 hours are shown in all cases). Two 48-hour periods are shown for female 1 at top and two 48-hour periods are shown for female 2 at bottom. The plots on the left hand side (A, C) depict diving activity and temperature immediately after surgical implantation of the instrument (the dark red vertical band shows time of implanting, the horizontal red arrow shows a 24 hour period after surgery). The plots on the right hand side depict diving activity and temperature on typical days 2 months later for each animal. Female 1 resumes normal diving activity and temperature within 24 hours (compare A to B), while female 2 exhibits reduced diving activity and slightly depressed temperature for the first 48 hours after surgery (compare C to D).*

c. Describe how the animals will react to your actions and the consequences of those reactions.

See attached USGS ASC IACUC-approved SOP: Sea Otter Capture, Chemical Immobilization, Routine Sampling, and Routine Surgery for more details on the following activities.

Capture of sea otters results in potential disturbance to animals that are in close proximity to captured animals but are not captured themselves. Tangle nets offer the greatest potential disturbance of the capture methods used while dip-netting and diver captures generally cause less disturbance. Because most captures will be by divers and median or average group sizes are between 1-3 otters, a reasonable approximation of disturbance would be 50-200% of the number actually captured. However, disturbance is of very short duration, less than 30 minutes, as the transport vessel arrives and departs quickly from the capture location. This incidental disturbance is similar to that caused by other boats (recreational, fishing, etc) operating in close proximity to sea otters. Precautions to minimize incidental disturbance will be to vacate the capture location as quickly as possible, avoid targeting large groups if possible, approach and depart via routes that do not interfere with foraging or traveling otters or other resting groups, and to stop using an area for a day or longer after a few disturbances have occurred (whether from successful captures or unsuccessful attempts). If harassment does occur, we will vacate the area as soon as possible to allow the otters to return to their normal behaviors.

Individual sea otters have variable reactions to our capture attempts. Most attempt to flee, though some individuals put up very little resistance. Their reaction to our capture attempts undoubtedly causes some degree of stress, as with any animal capture. We go to great lengths to minimize stress and handling time with these animals (see section D, below) by using experienced personnel and custom designed equipment, and our decades of research demonstrates that the reactions of the captured sea otters are acute/temporary, and once released, normal behavior is resumed, usually within 24 hours.

d. Identify how you would mitigate any potential negative effects.

It starts with our approach to capturing sea otters. The boat does not approach the animals directly and keeps a suitable distance away from the target otters. Disturbing or causing the otters to react is counterproductive to our entire capture effort, so we ensure that the otters are kept unaware of our presence until the moment of capture. Using divers whenever possible further prevents negative reactions from otters, since they are not becoming entangled in a net or being chased by a boat. The divers use highly advanced technology by employing oxygen rebreathers which vent no bubbles and are completely silent. These are the same rebreathers that are used by combat divers like NAVY SEALs in order to remain completely undetected. Not only does this technology increase our effectiveness, but being undetected by the otters also means that they do not react to our presence until absolutely necessary (at the moment of capture).

Once captured, the otters are transferred to a specialized holding box that has been custom designed to minimize stress and maximize comfort of the captured otter. The boxes are made of plywood and provide a dark space, which calms the animal. The boxes also have numerous holes in the sides and bottom which allows for air ventilation. These holes also permit the box to be partially submerged in the water, allowing the otter to thermoregulate using the cold sea water to combat any increase in body temperature that might result during the capture process. In our decades of experience employing this technique, the otters are remarkably calm once in the holding box. The box also has a PVC "false bottom" that allows any debris or fouling material such as feces to pass through the bottom and exit the box, keeping the inside of the box clean of any substance that could potentially foul the otter's coat.

Any negative effects of animal processing (collecting morphometric data, blood or tissue samples, and/or surgical implantation of instruments) are minimized by sedating the sea otter, so it is unaware of the procedures that are occurring. The sedative also has a minor short-term memory loss component associated with it, which will help the animal to forget the encounter once released, reducing any sort of stress that could possibly occur after release.

7. Do you plan to conduct activities with MARINE MAMMALS IN THEIR NATURAL ENVIRONMENT (i.e., in the wild) where "non-target" marine mammal and ESA-listed species occur in the United States? ("Non-target" species are species that are not the subject of your activities.)

a. A list of all non-target marine mammals and ESA-listed species that might occur in your project area or might be affect by your activities

Marbled Murrelet (Brachyramphus marmoratus)
California Least Tern (Sterna antillarum browni)
We anticipate that our activities will have no effect on marbled murrelets or least terns. In our experience, they are rarely encountered during our sea otter captures. We represent no greater risk to either of these species than any other boat on the water. In fact, we are less likely to affect murrelets because we are often traveling at slow speeds close to shore, where we are unlikely to encounter this species. The risk of encounter is even lower for least terns since they spend more time in flight and less time on the surface of the water than murrelets. Most likely, an encounter with least terns would involve the terns flying over or near our boats, resulting in no discernable impact to either terns or murrelets.

Leatherback Sea Turtle (*Dermochelys coriacea*)
Olive Ridley Sea Turtle (*Lepidochelys olivacea*)
We anticipate little to no impact on these chelonid species. Though leatherbacks do occur occasionally in these waters, they are almost always found in an open ocean/pelagic environment. We conduct our research in nearshore, shallow environments and are unlikely to ever encounter a sea turtle. Though tangle nets may represent a hazard to sea turtles in areas with dense turtle populations, we only set our nets in shallow waters, usually in or around kelp, where sea turtles are unlikely to occur. Although the scenario of a sea turtle getting caught in an otter tangle net is extremely unlikely, our protocols set forth in section 12(b) above, combined with our proposed amendment to the tangle net protocols in 12(b) insures that we will be able to quickly recognize and respond to an event where a turtle or any other non-target species becomes entangled in a net. Additionally, tangle nets are rarely used in California. Our primary capture method of using diver-operated Wilson Traps and dip nets, due to their precise and selective nature, presents no risk to either species of sea turtle.

Steelhead (Oncorhynchus (=Salmo) mykiss)
Steelhead do occur in coastal waters off Central California, but our operations represent little to no risk to this species. Our primary capture methods (diver-operated Wilson Trap and dip netting) represent zero risk to this species. Tangle nets could potentially represent a risk to larger steelhead if the nets are set near creeks where steelhead run. As mentioned above, tangle nets are rarely used in California and thus any interaction with this gear and steelhead is unlikely. However, we would take care not to set nets in close proximity to the mouths of known steelhead streams. Also, our protocols set forth in section 12(b) above, combined with our proposed amendment to the tangle net protocols in 12(b) insures that we will be able to quickly recognize and respond to an event where any large non-target species becomes entangled in a net. In many years of otter captures in California, not a single steelhead has ever been caught in a tangle net.

Blue Whale (Balaenoptera musculus)
Humpback Whale (Megaptera novaeangliae)
Southern Resident Killer Whale (Orcinus orca)
These three species of cetaceans do occur off the Central California coast, with the humpback whale being the most common of the three. Realistically, our sea otter capture techniques do not present a risk to blue, humpback, or killer whales. These whales are usually encountered off shore or in deeper water, while we are almost always working in very shallow, nearshore waters. Though we do see humpback whales occasionally, they are usually far away from any kelp forests or locations where we are trying to catch sea otters. With that said, we always exercise common sense when deploying a tangle net. If there is a high amount of cetacean activity in the vicinity, we would choose not to deploy a tangle net in that area. In the extremely unlikely event that one of these whales were to become entangled in a net, the procedures (including the proposed amendment) set forth in Section 12(b) insure that we would be able to notice the problem immediately (perhaps even before it happens) and respond quickly to either prevent entanglement or free the entangled animal.

Other marine mammal species that reside in our study area and could be impacted include: California sea lion (*Zalophus californianus*), Harbor Seal (*Phoca vitulina*), Bottlenose Dolphin (*Tursiops truncates*), Harbor Porpoise (*Phocoena phocoena*), Risso's Dolphin (*Grampus griseus*), and Gray Whale (*Eschrichtius robustus*).

These species, though not Federally-listed, are marine mammals that do occur in the vicinity of the Central California coast where we will be working. The impact of our operations on these species should be minimal. As previously mentioned, the use of diver-operated Wilson Traps and dip nets, by their precise and selective nature, present no risk to these marine mammals or any other species mentioned in this section. The use of tangle nets, however, does pose a slightly elevated risk to these smaller marine mammals. We minimize the risk by rarely using tangle nets in California. Still, there are rare times when tangle nets must be deployed. In such instances we take care not to deploy the nets if there is an abundance of non-target marine mammals (such as seals, sea lions, or dolphins) in the area. In the unlikely event that a non-target marine mammal should become entangled in the net, the protocols set forth in the tangle net methodology section 12(b), combined with the amendment proposed in section 12(b), insures that we will be able to notice and respond quickly if a non-target marine mammal were to become entangled in a net. Researchers would do everything in their power (including cutting the tangle net) to release the animal as quickly as possible. Given the low frequency of tangle net usage compared to our other techniques (Wilson Traps and Dip Nets), combined with the precautions taken when using tangle nets, we expect that the likelihood of our sea otter capture operations impacting other marine mammal species would be very low.

b. The maximum number of animals of each non-target marine mammal and ESA-listed species (# per species) that might be harassed by your activities, the precautions that you will take to minimize the likelihood that harassment will occur, and the actions that you will take should harassment occur;

In general, we do not expect to harass Federally-listed species or non-target marine mammals. The techniques of capturing otters by diver-operated Wilson Trap and dip net are very selective, precise, and accurate. This allows us to avoid harassing any species but the specific otters that we are targeting. The use of boats to conduct our work presents no greater risk to non-target species than any other boat on the water. In fact, our boats probably present less risk because we are diligent observers of marine life, we are usually moving at very slow speeds, and we generally work in shallow nearshore waters. When using tangle nets, the risk of harassment of non-target species increases, but remains extremely low.

Despite the low risk of harassment, we still take numerous precautions when using tangle nets. The deployment of nets is made under due consideration of predicted weather conditions: nets will not be set during periods of weather or sea state that may preclude their tending. Unlike in Alaska, tangle nets will very rarely be used in California, and only under circumstances where their use will (in the best judgment of the permit holder) represent a significantly lower risk of disturbance to sea otters and/or other marine mammal species. In cases where tangle nets are deployed we will also deploy 2 shore-based observers to monitor the nets and the entire vicinity of the nets (with a high-powered spotting scope) in order to detect the presence of non-target marine mammals. If there is detection of a non-target marine mammal, the nearby tending skiff will be called in to either pull the net or else remain beside the net until the marine mammals have left the area entirely. Additionally, at the time of net deployment, buoy-type floats will be attached to the float line at regular intervals (~10m apart) to increase the visibility of the float line and thus the likelihood that a shore-based observer with a telescope who was scanning that float line would be able to detect if even a small section of the net became pulled under water, signaling a possible entanglement. In such a case the tending skiff would be called in immediately to investigate (and release an entangled animal if that were the case). We believe both of the previously mentioned advanced monitoring techniques nearly eliminates the likelihood for unintended harassment of non-target marine mammals. At the very least, these protocols enable us to respond quickly and effectively, should unintended harassment occur.

10. Are you requesting to CAPTURE LIVE marine mammals in the wild? (i.e., for research, public display, or MMPA enhancement)

YES.

a. **A description of the manner in which the animal will be captured, type of gear used, and deployment method (e.g., from shore or boat approach and net deployment).**

Individual sea otters will be captured either in tangle nets, underwater diver-held traps (Wilson traps), or hand-held dip nets. All methods are routinely used throughout the range of the sea otter population (U.S., Russia, and Canada). Recapture of individuals will most likely be by underwater diver-held traps.

Diver-operated Wilson Traps

Our primary capture method involves using diver-operated traps to capture resting sea otters. Shore spotters with high-powered spotting scopes relay information about target animals to the dive crew. Divers work in pairs and each diver has a trap with a capacity for one adult sea otter, 2 juveniles, or a mother/pup pair. Otters must be resting (preferably sleeping) for this method to be successful. Divers use closed-circuit oxygen rebreathers and electric propulsion vehicles to maneuver the traps underneath the floating sea otters and engulf them with a net bag, which is closed by a purse line. The divers keep the animal and trap on the surface until the transport vessel arrives and the otters can be transferred to a sliding-lid capture box. Our research group has captured >600 sea otters in California, and >1000 sea otters in California, Alaska, Washington, Canada, and Russia combined, using diver operated Wilson traps with no trap-related mortalities. This method is highly selective, with zero chance for taking non-target species. Furthermore, this method allows us to target specific individuals, minimizing disturbance or harassment to non-target individuals.

Tangle Nets

Tangle nets are surface floating, un-weighted nets set in near shore waters in the vicinity of sea otters. Nets are typically 100 m long by 5 m deep (stretch mesh of about 22 cm), but may be modified to capture in shallow water. Each tangle net consists of stretch mesh hung between a positively-buoyant float line and a slightly negatively buoyant led line, and are suspended between large float buoys at each end which are anchored in place (ensuring sufficient anchor-line scope to avoid dragging the buoys below the surface under any tide or current condition). Nets are set out by a tending skiff and then monitored by the skiff and/or shore-based observers (see amendment request below). When one or more otters become entangled in the net, the skiff returns and extracts the otter(s), transferring them to capture boxes for transport to the processing site. The deployment of nets is made under due consideration of predicted weather conditions: nets will not be set during periods of weather or sea state that may preclude their tending. Unlike in Alaska, tangle nets are very rarely be used in California, and only under circumstances where their use will (in the best judgment of the permit holder) represent a significantly lower risk of disturbance to sea otters and/or other marine mammal species.

In an effort to minimize the chances of entanglements or by-catch of non-target species: 1) two shore-based observers with telescopes (instead of just one) will monitor a deployed net, with one observer continuously scanning the float line of the net in order to detect entanglements, and the second observer scanning the entire vicinity around the net for any marine mammal activity. In the event that any non-target marine mammals are detected in the area by that second observer, the tending skiff will be called in to either pull the net or else remain beside the net until the marine mammals have left the vicinity entirely; 2) at the time of net deployment, buoy-type floats will be attached to the float line at regular intervals (~10m apart) to increase the visibility of the float line and thus the likelihood that a shore-based observer with a telescope who was scanning that float line would be able to detect if even a small section of the net became pulled under water, signaling a possible entanglement. In such a case the tending skiff would be called in immediately to investigate (and release an entangled animal if that were the case).

Dip Nets

Dip-netting is a procedure where sea otters are dipped out of the water with a large fish-landing net. Open-water capture takes place from the bow of a small skiff, with one net handler and a vessel operator. This method is usually generally used to capture young animals. USGS personnel have been involved in the capture of >250 sea otters using dip-nets with no dip-net-related mortalities.

b. Methods of restraint and holding, including dimensions/type of holding container, if used;
The sea otters are transferred directly from the Wilson Trap, Tangle Net, or Dip Net, to a specially designed "otter box." These boxes have been customized over many decades of sea otter capture and handling, and represent the best possible temporary holding container for sea otters. Box materials, dimensions, and accessories have been designed and approved by both sea otter biologists and sea otter veterinarians with decades of experience in handling and transporting wild sea otters.

The boxes are made of marine grade plywood with an epoxy coating to protect the otters and the box itself. The epoxy also creates a smooth surface on the interior, and makes the boxes easy to clean. Wood is a desirable material because it is strong and sturdy, but still soft enough that the most uncooperative otters can chew it without damaging their teeth. The interior dimensions of the boxes are 36"L x 17"W x 22"H, providing more than enough room for an adult male sea otter, or a female and large pup. The box features a sliding plywood lid. By design, the walls and lid create a dark interior, which is believed by veterinarians and animal care experts, to have a calming effect on the animals inside. Our decades of field experience with these boxes has shown that the otters appear to be very calm once inside the box.

All 4 sides, and the bottom panel of the box feature 5/8" holes drilled at multiple levels for adequate ventilation. These holes serve another purpose though. The box may be floated in the ocean, alongside the boat, at any time. The holes allow water to enter the box, so that the otter can float inside the box. The cold seawater helps the otter thermoregulate, and helps to prevent any overheating that might potentially occur as a physiological response to the capture process.

Inside the box, a "false bottom" is installed. This is a PVC grate that allows refuse or materials such as feces to pass through the grate and exit via the bottom of the box, eliminating any chance of the material fouling the otter's fur. This keeps the interior of the box clean and tidy. Boxes also have canine "chew toys" (the kind you get at your local pet store) installed for the otter that like to chew. Chewing on a chew toy decreases the likelihood of the otters chewing on the wood box, while also giving them a distraction and enrichment experience while inside the box.

When otters need to be physically restrained (e.g. when being injective with the sedative) the procedure is done so in the safety of the otter box. A "stuff sack," which is a very soft cushion similar to a pillow but covered with a tough cordura exterior, is used to gently block the otter's head and shoulders while the vet administers the injection into the hindquarters. The process only takes a few seconds, and the otter usually uses the stuff sack as a chew toy.

c. **The holding time required prior to transport or release of the animal;**
Captured individuals will be transported from the capture location to the handling location in holding boxes that provide adequate ventilation. Ice or cold water will be provided as needed to keep the animals cool. Transport time will be kept to a minimum by co-locating capture vessels and handling/processing platforms. All animals will be released at or as near to their location of capture as is possible. Efforts will be made to process and release sea otters within 2 hrs of capture.

d. **Number and roles of personnel participating in the captures;**
The number of personnel involved in sea otter captures in California varies greatly, depending on the daily capture effort and/or the total duration of the capture event. However, it is not uncommon for the total number of personnel to number between 20-30 individuals. Roles are as follows:

<u>Diver</u>: 2 per boat, if multiple boats are used, there could be 4 or 6 divers working in teams of 2. The divers locate the target otters and perform the capture. They secure the otter in box, take local samples (water) and data (GPS, time, etc.), and transport the captured otter to the veterinary team on shore. This could involve dropping the otter off at the Monterey Bay Aquarium davit or a hoist on a pier, or transferring the otter shore via a beach-loading by inflatable boat, or transferring the otter to a larger vessel where the vet crew is operating. Depending on workload, the divers may also assist in animal processing and tagging. Diver's typically perform the releases of the otters as well.

<u>Boat Operator</u>: Assist with all the same duties as the divers, except the actual diving. Must be experienced otter spotter and skilled boat operator. Provides directions to the divers during the "capture run." Drives the boat and ensures the safety of the animals and the crew.

Boat Tender/Deckhand: Assist the Boat Operator in all tasks requiring assistance. Help secure and transport otters. Performs necessary duties of deckhand, including prepping and stowing gear, and assisting divers in and out of the water.

Shore Spotter: Usually in a team of 2, stationed on shore with binoculars and high-powered spotting scopes. Shore spotters are usually the ones that first locate the target otter, often using VHF radio telemetry (in the case of recaptures). Shore spotters relay location information and directions to boat crews and divers. During the capture run, shore spotters are able to assist the boat operator and tender by being and extra set of eyes (with a spotting scope). They can alert the boat crew or dive team to any changes in the status of the target otter, or if any hazards present themselves. The shore spotters also diligently monitor tangle nets, on the rare occasion that they are deployed.

Shore Team Coordinator: Orchestrates and oversees all shore-based operations from the time that the otters come ashore, to the time it is released or given back to the boat crews.

Veterinarian: Ultimately responsible for the well-being of the sea otters. Any judgement calls related to the health or safety of the animals are made by the vet in charge. The vet team performs surgeries, administers drugs, monitors anesthetized otters, and performs all examinations. Any data collected or procedures done on an otter once it reaches the vet team is supervised by the veterinarian.

Vet Tech: Assists the veterinarian and any and all duties required. May take samples/swabs from sea otters.

Blood Tech: Assists veterinarian and vet tech. Primarily responsible for obtaining, processing, and storing blood samples taken from the sea otters.

Data Tech: Responsible for recording a host of biological, morphological, and physiological data on every animal that is processed. Some examples of data collected: length, weight, tail length, paw width, age estimate, tooth condition, overall body condition, dental map of entire mouth, photos of mouth/teeth, baculum length, amount drugs or medication administered, reactions of animal (if any), details and timing of all procedures, etc.

e. **Duration of restraint/holding from capture to release; and**
As stated in (c) above, every effort is made to not exceed 2 hrs from time of capture to time of release. The otters are not physically restrained for this entire time. Most of the time is spent in the safety and relative comfort of the otter box, or anesthetized.

f. **The number of non-target individual animals of the target species that will be incidentally harassed during capture activities, and precautions you will take to minimize incidental harassment of non-target animals;**
During the most recent 5-year period the average number of sea otters incidentally harassed during capture activities was 54 per year (with a high of 93 in 2016). We expect the number to

not be above 100 in any year. The majority of these incidental harassment cases occur during diving captures using Wilson traps and are almost always due to the habit of sea otters resting in groups or rafts. When capturing target otters in a raft, nearby otters may be disturbed. We attempt to minimize the disturbance or incidental harassment of non-target otters. The rebreather diver techniques described previously are the best way to minimize incidental harassment because the divers remain undetected for the entire dive, until the moment of capture. Our captures are most successful when we are completely undetected, so minimizing incidental harassment is inherent to the success of our work. When possible, we avoid targeting an animal when it's in a very large group of otters. The odds of successful capture decrease when the target is resting in a large group. Sometimes this cannot be avoided, however, most capture attempts are on solo animals, animals in pairs, or otherwise small rafts.

g. **If capturing females with calves/pups/cubs, describe:**
Sea otter females and pups generally rest together, with the pup either on top of the mother, or alongside the mother, often in contact with one another. Since our studies often aim to answer questions pertaining to demography, population biology, and survival, we don't explicitly avoid capturing mothers and pups, as this would introduce a substantial bias. However, we also don't specifically target mothers and pups. Also, females may be captured without a pup, but recaptured later on, with a pup. We will not attempt to capture a female with a newborn or very small pup (1-2 weeks of age) because of the small size and vulnerability of the pup. When capturing mothers and pups, they will either be (a) captured together in the same Wilson Trap or (b) be captured simultaneously in 2 different Wilson Traps, depending on how far apart the mother and pup are from one another. It is possible that, if a diver made an error or had an equipment/trap malfunction, a female may be captured without her pup, or a pup without it's mother. Although such an occurrence is rare, it has happened in the past. In such a situation, the captured animal (either mother or pup) is immediately released from the Wilson Trap, allowing them to reunite with each other. We have never had an issue with the mother and pup not reuniting on their own in a situation such as this.

h. **How calves/pup/cubs will be held;**
Immediately after capture, the mother and pup will be transferred to a holding box, like all captured otters. In general, the mother and pup are placed in the same holding box. However, certain instances may dictate that holding the mother and pup in separate boxes would be the most prudent course of action. For example, if the pup is quite small and the mother is not showing clear maternal behavior towards the pup, it might be safer to keep the pup in its own box, to prevent any possibility of incidental injury to the pup. At the other end of the spectrum, sometimes very large pups are as big as the mother. In this case, the mom and pup might be placed into separate holding boxes so that both otters can have sufficient space. Mothers and pups, regardless of age or pup size, are always released together to reduce the chance of separation.

ii. Which procedures will be conducted on them;

Females with pup may be subjected to all the normal veterinary procedures that any captured sea otter would normally be subjected to. This includes surgery for the implantation of VHF radio transmitters and archival time-depth recorders (TDRs). In addition, sterile oxytocin (20 units/ml) may be injected intramuscularly to facilitate milk letdown in lactating females. Oxytocin, a hormone produced by the hypothalamus stimulates contraction of the smooth muscle of the mammary glands to release milk. We will only attempt to collect milk samples from females with dependent pups, no pregnant females or females without pups will be given oxytocin.

In general, the size of the pup dictates what samples, tags, or procedures are performed on the pup. The pup must weigh at least 20 lbs to qualify for and instrument implantation. Additionally, only pups greater 11 lbs will be flipper tagged.

iii. The duration of time the pair will be separated; and

Given that our estimated time from capture to release is 2 hrs, it's fair to say that the max time that a mother and pup would be separated is for this entire 2hr duration. In practice, the timing is much shorter, since the mother and pup usually share a holding box. If the mother is anesthetized for surgery, the pup will only be separated from the mom during the surgical procedure. This is typically <1 hr.

iv. Procedures used to reunite the pair, and if they do not reunite, explain the disposition of the calf/pup/cub.

We take all the necessary precautions to ensure that a separation of mother and pup does not occur. In fact, due to our precautions and the strong mothering instinct of female sea otters, a separation would be considered an extremely rare event. Therefore, reuniting a mother-pup pair is something that is almost never required in our work. As one of our precautions, we observe the behavior of the mother and pup together, in the holding box, to make sure their behavior is still indicative of a bonded pair (e.g. mother holding or grooming pup) before releasing them. We will also employ a "soft release" technique with moms and smaller pups. This method involves submerging the box on its side, about halfway in the water at the side of the boat, then slowly opening the door of the box. The otters will usually calmly swim out of the box.

However, in the extremely unlikely event of a separation, this would probably occur by virtue of the mother immediately leaving the holding box upon release, and leaving the pup behind in the box. This is only a concern with a small pup since larger pups are capable of swimming on their own and catching up to their mother. If a small pup is left behind in the box, the persons conducting the release will immediately remove the pup from the box and place it in the water to float. Releases are always done with the boat placed upwind so that the mother can smell her pup if she initially leaves without it. This will aid her in relocating her pup when she inevitably returns to look for it. In an extreme situation where the mother doesn't immediately return for the pup, the pup is held high in the air so that the sound of the pup's call can travel a greater distance, enticing the mother to return and retrieve her pup. If this still does not work, the pup will be left at the site of release, and the boat will back away. Our shore spotters will monitor the pup through a high-powered spotting scope to see if the mother returns to claim the pup. Should these attempts fail and the mother does not return, the pup will be rescued by the boat crew, and brought back into veterinary team. At the discretion of the lead veterinarian, if it is deemed that the pup has truly been abandoned, the pup may be raised in captivity at the Monterey Bay Aquarium as part of their surrogacy program, and could be released back into the wild once mature. We have never had to resort to this final step in many hundreds of wild sea otter captures.

h. A description of the use of drugs during capture, including:

i. Name of each drug/chemical used, its dosage rate (ml/kg), method of administration (IV, IM, SQ, topical and whether remotely-deployed IM), and purpose of the drug;

Chemical Immobilization / Anesthesia:

Approved personnel will immobilize sea otters following slightly modified procedures to those described in Monson et al. 2001, Chemical anesthesia of northern sea otters (Enhydra lutris): results from past field studies. In this paper, the benzodiazepine, diazepam, is one of the induction agents. Diazepam is well known for its inconsistent and unpredictable absorption when administered intramuscularly. An aqueous solution of a closely related drug, midazolam, is substituted milligram for milligram. As a result, expression of the effects of fentanyl, muscle rigidity and potential seizures is prevented.

Captured sea otters will be anesthetized in sliding-lid holding boxes using a combination of fentanyl citrate and midazolam hydrochloride (F/M) and reversed with naltrexone hydrochloride (N). This combination has been used successfully for the immobilization of over 1500 sea otters of both sexes, all age classes, and in varying states of physiological and/or pathological condition. There have been no anesthetic-related mortalities associated with this immobilization protocol in field settings to date. Fentanyl/Midazolam produces smooth inductions with little or no muscle tremors or convulsions while Naltrexone provides rapid, complete reversal of the opiate, fentanyl with no risk of re-induction. The holding boxes prevent premature escape of sedated animals while providing the captured otter a calm, quiet space. The observational access provided by these capture boxes facilitate close monitoring of sea otters as induction proceeds, as well as assurance that complete reversal, including return to normal body temperature, has occurred prior to release.

Intramuscular injections of fentanyl and midazolam are administered separately with different syringes at dose rates adjusted to the purpose of handling. Darting is not used because otters are usually in the water and the risks of drowning or 'struck and loss' are too great. We use target dose rates of 0.33 mg/kg of fentanyl and 0.11 mg/kg of midazolam for surgical procedures, and 0.22 mg/kg fentanyl and 0.07 mg/kg of midazolam for non-surgical, biological sampling procedures as recommended by Monson et al. (2001). If anesthesia is not complete after approximately 15 minutes, additional fentanyl may be given. If 2-times the initial fentanyl dose is incrementally reached, and sedation is still not complete, the antagonist is given and the animal released without further handling (this is rarely observed). In the event of excessive tremors or convulsions, additional intravenous midazolam may be administered. Inhalant agents, such as isoflurane or sevoflurane, may be used as needed should anesthetic depth be deemed inadequate by the attending veterinarian. Also, based on the best judgment of the attending veterinarian, local anesthetics such as bupivacaine may be applied when potentially painful procedures are considered in the case of animals that are immobilized with lower does or when anesthetic depth be deemed inadequate.

The reversal agent Naltrexone is administered intramuscularly, at a dose equal to 2-5 times the fentanyl dose, immediately following handling. In addition, sterile oxytocin (20 units/ml) may be injected intramuscularly to facilitate milk letdown in lactating females. Oxytocin, a hormone produced by the hypothalamus stimulates contraction of the smooth muscle of the mammary glands to release milk. We will only attempt to collect milk samples from females with dependent pups, no pregnant females or females without pups will be given oxytocin.

ii. Duration of drug and required holding time;

There are essentially two different doses of fentanyl/midazolam that are utilized. The lower dose is used for immobilization/restraint and provides approximately 60-90 minutes of sedation time. The higher dose level is the one utilized as an anesthetic dose and provides both immobilization and analgesia. The former will last for approximately 60 minutes with an additional 60 minutes of "restraint time" similar to that encountered at lower dosages.

There is an 8-12 minute lag time between the intramuscular administration of the drugs and effect. Both drugs have a reversal agent, however, typically only the fentanyl is reversed. Naltrexone is a direct antagonist requiring approximately 1-4 minutes to reverse the effects of fentanyl. It is metabolized more slowly than fentanyl, therefore re-sedation is not a problem. There is no post-reversal holding period required. Once animals are reversed, they are capable of being returned to the water and begin swimming immediately and foraging occurs shortly thereafter.

iii. The names of the personnel who would administer the drugs;

Michael Murray (DVM), Christine Fiorello (DVM), Nancy Anderson (DVM), Lesanna Lahner (DVM), Raymond Wack (DVM), Heather Harris (DVM), Christine Kreuder-Johnson (DVM), and Dave Casper (DVM).

iv. Provisions to minimize adverse reaction(s), including the use of appropriate drug reversals;

Drug doses are adjusted based on the physical appearance of the otter, information obtained by interviewing the capture team, and the anticipated level of chemical immobilization required. The lowest dose possible is administer. Reversal agents for fentanyl and midazolam, naltrexone and flumazenil, respectively, are always on hand in case of emergency. The naltrexone is always drawn into a syringe and ready for administration before induction agents are administered. Traditional emergency preparedness is practiced, with emergency drugs, endotracheal intubation equipment/supplies, and provision for oxygen administration on hand. In case of instability which cannot be readily managed, reversal agents are administered either intravenously or intramuscularly depending upon the situation.

v. Procedures to be used to minimize the chance that drugged animals will escape or enter the water prior to complete immobilization; and

Darting is not used because otters are usually in the water and the risks of drowning or 'struck and loss' are too great. Animals are drugged in the confines of a holding box (previously described in this permit application). As such, the otters are not near any water and cannot escape.

vi. Measures to be taken to ensure that the animal is fully recovered prior to release.

Naltrexone is the reversal drug that is administered. Naltrexone has a rapid onset and the initial "first response" time is typically noted within one minute. Monitoring by an experienced team member continues until reversal is complete and the animal is deemed releasable by the attending veterinarian. Monitoring and evaluation of the reversal is performed in the confines of the holding box. The otter is only returned to the boats/release crew once the vet has determined that it is fully reversed and ready for release. Typically, at least 10 additional minutes will pass from the time of transfer to the release crew to the actual release, since travel back to the site of capture is often required.

i. What emergency procedures would be employed (e.g., drugs, bagging, CPR, etc.) in the event that an animal's condition starts deteriorating during capture activities?

In case of emergency, traditional medical response protocols will be followed. If the otter has received immobilization drugs, their effects will be reversed with the appropriate antagonists, typically naltrexone and flumazenil. Additional emergency procedures, if needed, will follow the ABCD's of emergency medicine. A: establish airway. In sea otters this will involve the provision of supplemental oxygen. The otter may require tracheal intubation and intermittent positive pressure ventilation. B: breathing. Respiratory rates, effort, and effectiveness will be monitored. If need be, assisted ventilation with pure oxygen or ambient air will be provided. Pulse oximetry and/or blood gas monitoring will be done to ensure efficacy of respiration. C: circulatory. In cases of actual, suspected, or impending circulatory collapse, intravenous catheterization of the external jugular vein may be necessary. Supplemental fluids can then be administered to provide circulatory support. D: drugs. A spectrum of emergency drugs will be on hand in a well-stocked emergency kit. These drugs will be administered based upon the data obtained and interpreted by the attending veterinarian.

PART III

17. Explain how the proposed research meets the MMPA definition of "bona fide research," i.e., scientific research on marine mammals, the results of which: (A) are likely to be accepted for publication in a referenced scientific journal; (B) are likely to contribute to the basic knowledge of marine mammal biology or ecology; or (C) are likely to identify, evaluate, or resolve conservation problems.

The research conducted under this permit will result in creation of manuscripts likely to be accepted in scholarly/peer-reviewed journals, based on our past research activities (see citation list of peer-reviewed publications based on research conducted under prior versions of this permit). This research will also be beneficial to evaluation and remediation of anthropogenic factors that may contribute to sea otter mortality and thus prevent recovery of this stock. Additionally, data and samples collected under this permit will add to the basic knowledge of sea otter biology and ecology, allowing better informed management and conservation decisions.

18. Provide a detailed description of the proposed project. You may attach a formal research proposal, provided it includes all the requested information, including:
a. Objectives and hypotheses and associated methodology;
b. Background information discussing relevant published literature on the subject of your proposal, with citations;
c. An explanation of how this study is different from, builds upon, or duplicates past research;
d. An explanation of how you determined your sample size/take numbers (e.g., based on previous encounter rates or abundance estimates for the study area). If appropriate for your study, include a power analysis or other sample size estimation to show whether the sample size is sufficient to provide statistically significant or otherwise robust results appropriate for your study;
e. If proposing novel procedures, include a discussion on results from pilot studies or studies on other species, if available; and
f. Disposition of animals or remaining specimen material once your project is complete.

Pleased see the enclosed documents for the proposals for 3 studies that are currently in progress.

In brief, the Monterey NSF Predator Diversity Study is investigating the impact of a sudden loss of a meso-predator (sea stars) on kelp forest community composition, and the the ability of sea otters to mitigate the loss of other predators in the system through behavioral plasticity. The study has the potential to redefine the role of sea otters in kelp forest communities. The results may elucidate the mechanism by which otters "control" urchins/grazers, and will demonstrate why simply having a healthy sea otter population may not be the only requirement for healthy kelp forest ecosystems in California.

The on-going San Nicolas Island Sea Otter Population Monitoring work is a continuation of a multi-decadal survey that monitors the status and growth or decline of a translocated population of sea otters at San Nicolas Island. The US Navy is funding additional monitoring work that involves diet and behavioral observations. The project utilizes a tiered approach, based on the findings of our research. If survey numbers drop below a critical threshold, or if sea otter deaths as a result of US Navy activities are observed, the project would advance to the next tier, and may eventually require the capture, tagging, and intensive monitoring of sea otters at San Nicolas Island.

The Tagging Technology project is described elsewhere in this application, but this joint NASA-USGS venture aims to utilize state-of-the-art technology to finally incorporate GPS data in a sea otter tag, allowing for more accurate and frequent resights of sea otters with much less effort/personnel. Moreover, the tags are being designed to work in a mesh-network, where individual otters will resight each other, via tags that communicate with one another, and offload their data to base stations whenever they are in range. This tagging technology is cutting edge, and will greatly advance our knowledge of sea otter ecology, behavior, movements, and interactions. It will also present a less invasive alternative to studying sea otter behavior.

19. Provide the expected research schedule (clearly specify the proposed start date and end date of your research or field season(s) and overall duration of the project). Include the months of the year and frequency of fieldwork/sampling (e.g., number of times per year). If your research extends beyond five years, or is a continuation of previously authorized research, give information about when the research began and when you expect it to end.

Our research program has been essentially continuous since 1998, and is part of a long-term monitoring and research program mandated and supported by the Federal agency responsible for management of this species. Research is ongoing at sites throughout the sea otter's range in coastal California (see research proposals above), and these (or similar) studies are anticipated to continue throughout the 5-year period covered by the permit. Because of the broad, comparative nature of our research, and the need to obtain representative data from throughout the range (and over all seasons and across years) on all population parameters, sampling may occur at any location within the current range of southern sea otters (see attached map, Figure 2) and at any time of year within the time period covered by the permit.

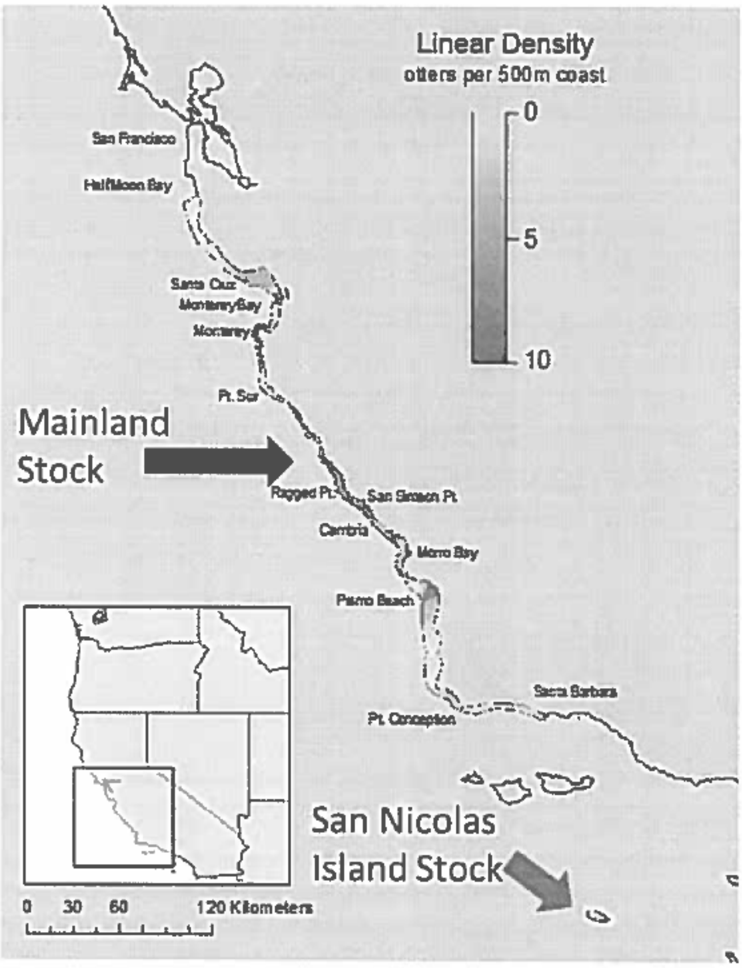


Figure 2. *Range of the Southern sea otter population showing the separation of the two stocks. Sea otter distribution shown as colored band along the coast, with warmer colors corresponding to higher sea otter densities.*

20. Indicate which research procedures/activities you will be conducting that will or might result in **TAKE or HARASSMENT of TARGET species**, and describe each activity in detail, including the information indicated in a-i, below.

Take or harassment of targeted sea otters will occur when sea otters are captured by one of three methods (described in detail in section 12b): tangle nets, underwater diver-held traps (Wilson traps), or hand-held dip nets. All methods are routinely used throughout the range of the sea otter population (U.S., Russia, and Canada). Recapture of individuals will be by underwater diver-held Wilson traps.

Because of the broad, comparative nature of our research, and the need to obtain representative data from throughout the range (and over all seasons and across years) on all population parameters, sampling may occur at any location within the current range of southern sea otters (see attached map, Figure 2) and at any time of year within the time period covered by the permit.

See attached USGS WERC Santa Cruz Field Station IACUC-approved SOP: Sea Otter Capture, Chemical Immobilization, Routine Sampling, and Routine Surgery for more details on capture and sampling methods.

a. Administration of drugs (including emergency drugs and prophylactic antibiotic use) or other substances (e.g., stable isotopes); include i-vii, below, in your activity description:
i. Name of each drug/chemical used, its dosage rate (ml/kg), method of administration (IV, IM, SQ, topical and whether remotely-deployed IM), and purpose of the drug;
ii. Duration of drug and required holding time;
iii. The names of the personnel who would administer the drugs;
iv. A description of specific State requirements regarding who (e.g., attending veterinarians, vet technicians, researchers) may handle and administer certain drugs;
v. Provisions to minimize adverse reaction(s), including the use of appropriate drug reversals;
vi. Procedures to be used to minimize the chance that drugged animals will escape prior to complete immobilization; and
vii. Measures to be taken to ensure that the animal is fully recovered prior to release.

Please refer to Part I Sections (h) and (i), as all of the above was described in that section.

b. Aerial and vessel surveys (manned); include i-v, below, in your activity description:
i. Type of survey craft and vessel;
ii. Type of survey (e.g., line transect, photogrammetry);
iii. Number of surveys per year;
iv. Minimum and maximum altitude/approach distance; and
v. Duration spent with group or individual per day.

We are not requesting any takes as part of aerial or vessel surveys.

c. Aerial surveys using unmanned aircraft systems (UAS); include i-xii, below, in your activity description:
i. Dimensions, mass, and battery life of UAS;
ii. Will the UAS ever be beyond the line of sight?
iii. Does the device have an auto-return feature should the device fail?
iv. Ground control station description (what it is, where it will be located, e.g., on shore or on vessel, number of stations, and how close the station will be to animals);
v. Spotter roles (e.g., one spotter monitoring the UAS, another for monitoring the ground control station);
vi. Do you have the appropriate FAA permits/authorizations (including pilot licenses)?
vii. Type of survey (e.g., line transect, photogrammetry);
viii. Number of surveys per year;
ix. Minimum and maximum altitude/approach distance;
x. Duration spent with group or individual per day;
xi. The names of the personnel who will pilot the aircraft, and

xii. Mitigation measures you will use to minimize disturbance including specific measures you will use to avoid separating female-calf/pup/cub pairs, and measures to ensure the UAS will not collide or crash into any of the animals.

At this time, we are not requesting takes as part of UAS surveys. We hope to use UAS in the future for a variety of applications, however, we are currently not using UAS at present. If the need arises in the future, we will submit a request for an amendment to our permit.

d. Capture and restraint; if you will be capturing animals, ensure that you have completed question 10, above.

Question 10 has been completed.

e. Instrumentation, Marking, and Tagging (MTI); include i-x, below, in your activity description:
Refer to Lander et al (2001) for an overview on sea otter tagging, including flipper tagging, PIT, and VHF. See attached USGS WERC Santa Cruz Field Station IACUC-approved SOP: Sea Otter Capture, Chemical Immobilization, Routine Sampling, and Routine Surgery for more details on the following tagging methodologies.

i. The type of MTI (including dimensions and mass);

Flipper Tags
Generally all animals captured > 11 lbs will be visually tagged to prevent repeated sampling of the same individuals. Temple tags, used on the hind flippers, are 45 x 14 x 2 mm, and weigh ~7g. Because long-term tag retention rates are <100% (Ames et al. 1982, 1983) each sea otter may also be marked with a coded, passive transponder chip, implanted subcutaneously in the inner thigh. When flipper-tagging, holes are punched using a sterile leather punch (hole diameter <5mm). Flipper tags have been used extensively in sea otter research and rehabilitation effort without any observed deleterious effects.

In addition, we request the ability to use newer electronic "smart" flipper tags in place of 1 or more of the traditional Temple Tags described above. The smart flipper tags will be of comparable size any weight, but are still being developed and tested. These smart tags will have GPS capability, as well as network capability, allowing them to "talk" to the tags on other otters, relaying information to a base station when in range. They are solar-powered and may include other additional sensors like an accelerometer, wet/dry switch, etc. These tags are being developed in a collaboration between USGS and NASA. Concurrent to tag development, different materials and form factors are being tested on captive sea otters at the Monterey Bay Aquarium. These smart tags will be capable of collecting geo-location data and/or conducting otter-shore or otter-otter communications, and we anticipate that eventually they will replace the implantable VHF transmitters as a less-invasive, primary means of sea otter tracking/monitoring. The form-factor and attachment method are similar to the temple tags, and these smart tags would only be deployed on wild otters (in place of temple tags) once enough testing has been conducted with captive otters to ensure that there is no negative response to these tags.

PIT Tags
Implantation of "passive integrated transponders", or PIT tags, may be done to facilitate identification in the event of external tag loss. PIT tags have been safely used in multiple species of all sizes, including sea otters, without deleterious effects to survival. 125 MHz tags, approximately 13 x 2mm, will be injected into the left inguinal area using a 12 gauge needle and syringe. Tag, needle, and syringe are gas-sterilized together in a package or come pre-sterilized from the manufacturer (Biomark, Boise, ID). PIT tags are encased in biocompatible glass which protects the electronics while preventing adverse effects to the animal. All captured otters will be scanned prior to initiation of sampling/external tagging for identification and to access prior capture history.

VHF Radio Transmitters & Archival Time-Depth Recorders (TDRs)

For some aspects of our research, use of electronic signaling tags is necessary. VHF radio transmitters (80 x 22 x 50mm, ~160g, Advanced Telemetry Systems, Isanti, MN) and time depth recorders (TDRs, 67 x 17 x 17mm, ~27g, Wildlife Computers, Redmond, WA) are standard instruments that are currently surgically implanted in sea otters. Radios are potted in a waterproof electrical resin and coated with a USP Class VI material (United States Pharmacopeia, Class VI requires the most stringent testing). TDRs are potted in a hydrolytically stable material and coated with a non-bioreactive coating. Instruments are gas-sterilized and sealed in surgical steri-peal pouches for storage until used. This procedure has been successfully completed on several hundred sea otters in Alaska and California with very low rates of mortality (< 0.2%).

ii. The maximum number and total mass of MTIs to be attached to/implanted in an animal at a given time;

Each otter will be tagged with unique color/number coded polyethylene "Temple Tags" (livestock ear tags, Temple, TX) in their hind flippers (typically 2 tags per otter [1 per flipper], no more than 4 tags [2 on each flipper]). The minimum total mass of 2 flipper tags would be a combined 14g, with the maximum (4 tags) equaling approximately 28g.

A maximum of 1 VHF radio transmitter will be implanted (total mass ~160g). A maximum of 1 TDR may be implanted (total mass ~27g).

iii. The maximum dart penetration depth if MTI is attached via darts;

Not applicable. We do not use darts.

iv. Methods and location of attachment, including minimum approach distance for remote MTI attachment;

Please see question 10 for a detailed account of how otters are captured and tagged. Also refer to (e) and (i) above. In addition:

Surgical Implantation Procedure

VHF transmitters and TDRs are internally implanted, rather than being externally attached as in many marine mammal species, because 1) sea otters are unable to tolerate external attachments that might compromise their pelage (which is critical for thermoregulation), and 2) attached instruments similar to those used on pinnipeds would compromise their swimming and foraging abilities because of their small size. Furthermore, because of the nature of sea otter grooming activity, they are capable of reaching and removing (or destroying) most existing types of externally-attached tags.

Consistent with sound veterinary surgical practice, abdominal surgery, including implantation of VHF and/or TDR's is done with aseptic technique. Modifications of traditional methods are necessary, however, in order to accommodate the need for immediate post-operative return to the wild and preservation of the integrity of the sea otter's pelage due to its importance in thermoregulation. Rather than shaving the fur from the surgical site, the fur overlying the ventral midline is parted with a fine-toothed comb and held in place with a combination of water soluble, sterile surgical lubricating jelly and aqueous 10% solution of povidone-iodine.

Access into the abdominal cavity is through an appropriately sized (6-10 cm) incision through the linea alba. Individually sterilized VHF transmitters and/or TDR's are then placed directly into the abdominal cavity, or in the case of TDR's may be inserted into the adipose tissue stored in the falciform ligament. If deemed necessary by the surgeon a solution of diluted antibiotic may be infused into the body cavity prior to closure.

A multi-layer, typically consisting of 4 separate suture lines, linea alba, subcutanesous fat/muscle, subcuticular, and skin, closure is meticulously performed to assure a water-tight seal, as well as to mitigate the potential for dehiscence either due to technique or self-mutilation. A sterile, mono-filament suture which is minimally reactive, provides adequate longevity, yet is absorbed over time is used to close surgical incisions.

In addition to the process described above, additional safeguards are applied during instrument extraction/replacement surgeries. Since surgeries of this nature are more invasive with larger incisions, and greater duration, additional prophylactic measures are taken. In addition to the surgical drapes attached to the skin a secondary sterile draping system is utilized being affixed to either the subcutis or through a specialized sterile wound retractor.

A broad spectrum, extended duration antibiotic is administered in conjunction with surgery. Any significant pathology encountered intra-operatively will be investigated within the limits of the patient's wellbeing. A record of the surgical procedure and associated findings is completed following each procedure.

v. If surgeries for implantable tags are being conducted, specify who will be conducting them, where (in the field or in a facility), and if antibiotic prophylactics will be administered;

Per the previous description in (iv), surgeries to implant VHF radio transmitters and occasionally, archival time-depth recorders, will be conducted by authorized veterinarians listed on this permit. The lead veterinarian (usually Dr. Mike Murray of the Monterey Bay Aquarium) supervises other vets and vet techs working under him. For captures in the vicinity of Monterey, surgeries and animal processing will be done in the state-of-the-art Animal Health Lab at the Monterey Bay Aquarium. For captures in more remote locales, surgeries may be conducted in an advanced mobile vet lab (provided by the California Department of Fish & Wildlife) or on a large research vessel in even more remote areas. Prophylactic broad spectrum, extended duration antibiotics will be administered in conjunction with surgery. Refer to (iv) above, the attached SOPs and the veterinary section of question 10 for more information on surgery and antibiotics.

vi. The maximum number of times an animal would be fitted with MTIs in a given year;

Because the flipper tags are made of plastic or some other similar soft material, they may occasionally be chewed off by the sea otters. This is by design, since the soft plastic will not harm the teeth of the otter. We request the ability to recapture an individual to replace flipper tags no more than 3 times per year, with a minimum of at least 3 months between captures of the same individual. There could be a need to collect additional blood or tissue samples, which can be done at the same time as the flipper tag replacement. We will make an attempt to recapture otters equipped with TDRs in order to retrieve/explant the TDR instrument so that the archival dive and temperature data can be downloaded. Recapture for TDR explant will take place any time after the implant and release, provided at least 6 months has passed since the initial implant of the TDR. We may also recapture an otter to replace the VHF radio if the battery begins to die. Typically, VHF radio batteries last approximately 3 years, for recapture for the purpose of implanting a new VHF radio (if deemed appropriate, for the continuation of the study), would occur once after 2-3 years. Replacement surgery would be performed no more than one time on any given animal.

vii. Will recapture be necessary (if so, how many times will animals be captured annually), would the instrument/tag have a release mechanism, or would the instrument/tag fall off?

Per the previous response (vi), recaptures are necessary for two main reasons. (1) to replace flipper tags that have been chewed off by otters and (2) to explant TDR instruments. Because the TDRs and VHF radios are surgically implanted, there is no release mechanism. A third reason, as described above, would be if it is deemed necessary to replace a dying VHF radio with a new radio. This would be a rare occurrence, and would happen only once after at least 2 years from the original radio implantation.

viii. Have the proposed MTIs been used previously on this species?

The Temple Tags, PIT tags, VHF transmitters, and TDRs have been used for many decades on hundreds (or in the case of PIT and flipper tags, thousands) of sea otters, with a very high success rate.

The "smart tag" flipper tags have not yet been deployed on wild sea otters, since they are a cutting-edge technology that is still in development. However, the form factor of these new smart flipper tags will be nearly identical to a Temple Tag, so we don't expect the otters to react to these tags any different than they would the Temple Tags. Regardless, the new tags are undergoing extensive testing on captive sea otters at the Monterey Bay Aquarium, to ensure that they have no adverse impacts on sea otters. Only once we are happy with the results on the captive sea otters, will we deploy this new tag on wild sea otters.

ix. What are the potential adverse effects and the means of monitoring new MTIs for adverse effects?

See previous response. However, the only new MTI is the smart flipper tag. Because these tags haven't been used before, and because they are still being developed, it's impossible to know with 100% certainty what adverse effects they might have. However, because the size, weight, and form factor is nearly identical to the existing Temple Tags that have worked remarkably well for decades, we don't anticipate any adverse effects from these new smart flipper tags. As previously mentioned, the new tags are currently undergoing rigorous testing on captive sea otters at the Monterey Bay Aquarium to ensure that they have no adverse impact on the host otters. Once we are satisfied with captive testing, we will deploy the tags on wild sea otters. Given the nature of our research projects, we have observers visually locating the tagged otters multiple times a week (and sometimes daily), which gives us a mechanism for monitoring the well-being of the otters, and any potential adverse effects of the new tags, in real time. If an otter appears to be in severe distress as a result of the tag, we have the capability of deploying a team to capture the otter to help remedy the situation and/or get the otter the treatment it requires from qualified veterinary personnel. The nearshore habits of sea otters allows for a level of direct visual monitoring that is impossible with most other marine mammals.

x. What actions will be taken in the event that the MTI has a significant adverse impact on the animal(s), and what is the method of animal release from the MTI?

Per the previous response, if a significant adverse impact is detected by our visual observers, a team of divers can be deployed to recapture the otter in question. Depending on the nature or the impact or distress, it may be remedied on site, or the otter may be brought in to qualified veterinary personnel for examination and/or treatment.

f. Intrusive sampling (e.g., blood, blubber, muscle, skin); include i-xiii below, in your activity description:

Each captured or sampled otter will be given a unique ID number. All specimens collected from an otter will be marked with that unique ID as well as sample type and date of collection. The following table (Table 1) provides details of the types and sizes of samples to be collected as well as storage details. Collection of these samples is standard and was previously permitted under MA672624.

Table 1. Listing of samples and their research uses collected from captured sea otters and/or beach-cast remains. Note that some samples may be collected from both live captured animals and carcasses, while some can only be collected from one or the other. All samples listed have been approved on our previous permit.

TABLE 1. Samples authorized for collection from captured sea otters or beachcast remains

Sample Type	Live/Carcass	Amount Collected	Use	Comments
Blood	Live	5% blood volume (blood volume = 8% BW	Hematology, clinical chemistry, infectious disease monitoring, biomarkers, contaminants	Blood volume "lost" from animal to include collection, loss to hematoma, bleeding from tagging, and surgical bleeding
External swabs (integument, oral cavity, rectum, genital orifice	Live	No volume limitation	Infectious disease (bacterial, fungal, parasitic, viral), contaminants, genetics	
Saliva	Live	0.3 - 1.0 ml	Hormonal assays	
Feces	Live	No limit	Diet assessment, infectious disease (bacterial, fungal, parasitic, viral), contaminants, biotoxin, hormonal assay	From environment
	Live	< 100gm		Collected from rectum
Milk	Live	< 10 ml	Nutritional content, fatty acid analysis, contaminants	May require administration of oxytocin to cause release
Urine	Live	TBD by DVM	infectious disease, toxins, urinalysis, contaminants	Free catch or cystocentesis
Adipose tissue	Both	< 10 gm (live)	Fatty acids, contaminants	May require surgical intervention with appropriate consideration for anesthesia and surgical methodology.
		No limit (dead)		
External pathology (integument, oral cavity, genital orifice)	Both	TBD by DVM	Histopathology, genetics, etiopathogenetic investigation	May require surgical intervention with appropriate consideration for anesthesia and surgical methodology.
Liver biopsies	Both	< 2 gm (live)	Histopathology, toxicology, contaminants, genetics, chemical analysis (ie, Vit A analysis)	May require surgical intervention with appropriate consideration for anesthesia and surgical methodology.
		No limit (dead)		Collected at necropsy
Premolar tooth	Both	1	Cementum aging	First upper premolar, only
Skin plugs	Both	< 2 gm (live)	Genetics	Collected in association with flipper tagging in live animals
Vibrissae	Both	2	Stable isotope	
Baculum	Carcass	1	Morphometrics, stable/radio isotopes	
Tooth	Carcass	No limit (dead)	Cementum aging	
Skull	Carcass	1 or portions	Morphometrics, stable/radio isotopes	
Fur	Both	NMT 1 gm	Hormonal assays, toxins, contaminants	Collected by plucking as not to interfere with thermoregulation.

i. Will sampling be remote or under restraint?
The otters will be anesthetized during sampling.

ii. Will local anesthetics be administered?
A general anesthetic is used.

iii. Type of tissues sampled;
Refer to Table 1, above.

iv. Size or volume of sample (diameter and depth or total volume);
Refer to Table 1, above.

v. Target sampling location on body;
Refer to Table 1, above.

vi. Maximum number of samples per animal per day and per year;
Refer to Table 1, above.

vii. Sampling intervals (e.g., for serial blood or biopsy samples);
Samples taken at the time of recapture. As previously state, recaptures, and therefore sampling, will never occur more often than at 3-month intervals, though in practice, most recaptures are annual, or even less frequent.

viii. Collection method and equipment/materials used (e.g., dart fired from rifle, dart depth, sterilization/disinfection);
Refer to Table 1, above. Also, all samples are taken while the animal is "on the table" and anesthetized. The equipment and materials used are all standard medical/veterinary tools that would normally be used in a lab or surgery suite.

ix. If remote, what is the minimum approach distance?
N/A

x. If restrained, describe treatment of site of sample collection (e.g., cleansing, wound left open or closed);
Otters are anesthetized and most samples are minimally invasive (refer to Table 1). For samples that may draw blood (blood sample, premolar sample) the site may bleed and is treated with gauze in the same way you would treat a blood draw in a human.

xi. Number of attempts per animal per day (include total number of attempts needed for all work if requesting multiple procedures (e.g., remote tagging and biopsy) on same animal on the same day);
Because sampling is only done at the time of capture, this is only 1 attempt to collects the necessary samples for each capture/recapture.

xii. The names of the personnel who will conduct the sampling; and
Michael Murray (DVM), Christine Fiorello (DVM), Nancy Anderson (DVM), Lesanna Lahner (DVM), Raymond Wack (DVM), Heather Harris (DVM), Christine Kreuder-Johnson (DVM), Cara Field (DVM), Shawn Johnson (DVM), Claire Simeone (DVM), Dave Casper (DVM), Melissa Miller (DVM), Marissa Young, and Michelle Staedler.

xiii. Sample preservation and analysis.
Refer to Table 1, above.

g. Non-intrusive sampling (e.g., behavioral observations via focal follows and ground surveys, scat collection, passive acoustic monitoring and recording, photo-ID, photogrammetry, remote video monitoring, underwater photography); include i-vi, below, in your activity description:
i. Approach, sampling methods, and platform type;
ii. Minimum and maximum approach distance (specify different distances for each deployment method);
iii. Are researchers within sight of animals or not (e.g., from a blind)?
iv. Frequency of observations/sampling;
v. Duration of observations/sampling per day; and

vi. If conducting underwater photography/videography, specify the method (e.g., snorkeling, underwater pole cam, or divers using typical gear or rebreathers) and number of people in the water at a given time, including the safety diver/snorkeler.

For all the above, our non-intrusive sampling involves the visual monitoring of tagged sea otters in order to collect a suite of bio-behavioral and geospatial data associated with sea otter population biology, survival, and movement patterns. Most of the observations are done from shore and utilize binoculars and high-powered spotting scopes. This means that observations are completely non-intrusive and the otters don't even know that they are being observed. Observations are sometimes conducted daily, but at the very least, multiple times per week for the duration of a single study, which may last an average of 3 years. Each otter is located daily (if possible) to obtain resight data. Individual animals may undergo focal follows in order to collected detailed foraging data or activity session data. Foraging follows may last for the duration of the foraging bout, from a few minutes to a few hours, depending on the sea otter and how mobile that animal is during the foraging bout. Activity sessions are focal follows that last 6-24 hrs. However, the observers are never within sight of the otter during the collection or resight, foraging, or activity session data. On rare occasion where shore access is not possible, we will attempt to conduct the same types of observations via boat. When using a boat, we maintain a respectable distance that is determined to have no effect on focal otter's behavior. If we were to do anything that caused the otter to notice us or change its behavior, it would undermine our entire research program, since our observations and data are intended to reflect the behavior of wild sea otters, and altering the behavior of an otter in any way is in direct conflict with our intended research.

h. Testing methodologies on captive-held animals; include i-iii, below, in your activity description:
i. A description of the methodologies and equipment to be used;
ii. Duration and times of testing and data analyses; and
iii. Methods used to decondition the animals that will be released to the wild after testing.

Note that although we are currently testing new smart flipper tag technology on captive otters at the Monterey Bay Aquarium, the testing falls under the conditions of a separate captive and rehabilitation permit that is issued to the Monterey Bay Aquarium. They are a collaborating institution with many aspects of our research program, especially the projects involved with advancement in tagging technology. We do not request any separate or new approvals to test methodologies on captive otters, since our current collaborative activities are permitted under the existing captive permit at the Monterey Bay Aquarium.

i. Other procedures/activities; list each additional procedure/activity and provide a detailed description of each, including all appropriate mitigation measures (note, we might contact you with follow-up clarification of methodologies), novel procedures, and any procedures involving active acoustic or hearing studies).

We are requesting a continuation of the collection of salvaged specimens (carcasses and/or parts) from beaches and the clarification that this may occur throughout the range of the Southern sea otter, and beyond, since dead otters sometimes wash up extralimitally and present especially interesting cases when determining the cause of death. See Table 1 for more information. The recovery of sea otter carcasses provides an invaluable opportunity for determining the most important causes of death and threats facing the wild sea otter population. We work with our partners at the California Department of Fish & Wildlife to recover and necropsy beach-cast sea otter carcasses throughout the state.

21. For each procedure/activity, provide the information in a-j, below, including the maximum number of animals of each species expected to be taken by the procedure annually, broken down by sex and age class; the number of takes per animal per year; and an estimate of the number of animals of the study species that might be incidentally harassed (i.e.,# of non-target animals of your study species that might be harassed by your activities). Also, include the time-periods and specific locations of the takes. This information may be provided in table format such as:

Note that we have modified this table to reflect the number of takes we have left on our current permit.

Table 2

	a. Species	b. Procedure/ Activity	c.Level A or Level B Harassment *or other Take**	d.Age Class (see question 23, below)	e. Sex	f.Max. # Animals Per Year	g.Max. # Takes Per Animal Per Year	h.Max. # non- target conspecifics incidentally harassed	i.Time-period	j. Location
Leftover from current permit	*Enhydra lutris nereis*	Capture 606								Entire Range
New takes requested	*Enhydra lutris nereis*	0	1250	-	-	-	-	-	-	-
Total of leftover + new	*Enhydra lutris nereis*	606	1250	All	Both	120	3	250 per year	5-year permit duration	Entire Range

Table 3: We are not requesting additional Total Takes (606 remaining), the number permitted for Anesthesia/Tag/Tissue Sample (291 remaining) or the number permitted for Surgery Implant/Explant (153 remaining). We are requesting authorization for Level B harassment of up to 1250 (250/year) during capture activities.

	TOTAL TAKES (CAPTURES)	TOTAL FOR ANESTHESIA/TAG/TISSUE SAMPLES	TOTAL FOR SURGERY IMPLANT/EXPLANT	LEVEL B HARASSMENT (FOR 5 YR DURATION OF PERMIT)
# REMAINING FROM OLD PERMIT	606	291	153	1250

Southern Sea Otter and to compare populations across geographical regions, wild animals from those populations must be sampled. When possible, data and/or samples will be obtained from beach-cast carcasses rather than live-captured animals.

Our methods have proven efficient and effective for many decades, but more importantly, they have also been refined at every available opportunity. We have learned a lot over the years and we believe that our current techniques represent the best and safest methods in existence, for this type of research.

Please refer to the methods in Question 10, and in this most recent section, as well as our IACUC SOPs, and numerous published peer-review papers provided in this application, that describe our protocols for sea otter capture, tagging, bio-sampling, anesthesia and surgery, as these provide a detailed description of the procedures we have implemented over the past 20+ years in order to reduce the likelihood of adverse health impacts, mortalities, pain, or suffering. Some of the protocol changes that we have made to reduce the likelihood of adverse effects include wrapping of plastic hose around all metal parts of Wilson traps and dip nets that otters could potentially bit so as to prevent tooth damage, extensive improvements to capture boxes (increased ventilation, no "bitable inner edges", false bottoms that keep the otters fur separate from water or fouling materials), reducing total animal processing time to under 2 hours, better management of otter thermal conditions prior to surgery (including sea-water soaks immediately prior to anesthesia), modification of the anesthetic and surgical procedures to reduce overall invasiveness and improve recovery time, and switching to temperature-sensitive PIT tags so as to be able to closely monitor body temperature in real-time after drug reversal (but prior to release) to ensure appropriate surgical recovery. Because of these and other protocol changes, we have continued to improve the outcomes for study animals and reduced the potential for accidental lethal takes to very low levels, while also minimizing any pain and suffering that the otters might incur. We take this very seriously, and have spent untold hours and funds ensuring the well-being of the sea otters we capture.

26. Provide: a) an estimate of the possible number of unintentional deaths or serious injuries that might result from your research activities; b) the number of unintentional and intentional (via euthanasia for humane purposes if an animal is seriously injured) deaths or serious injuries you seek approval for annually; c) the steps you will take to reduce the likelihood of deaths or injuries; and d) if euthanasia might occur, provide the method of euthanasia (e.g., gunshot, drug, etc.) and who would conduct the euthanasia procedure.

Our current permit requires notification of the permit office after one mortality that occurs during capture operations (where there is reasonable cause to suspect that the death was caused by our activities and is thus an accidental lethal take), and cessation of all activities after 2 such mortalities. We would therefore request no more than 2 accidental lethal takes for this permit renewal (with the specification that post-mortem necropsies by a veterinary pathologist indicate that the mortalities in question were indeed caused primarily or entirely by our activities rather than by some unrelated factor). In the unlikely event that a moribund animal needs to be humanely euthanized, this will be determined by the lead veterinarian, and euthanasia will be by drug injection.

28. If a female animal accompanied by calf/pup/cub(s) dies during research activities, specify the disposition of the associated calf/pup/cub(s).

In this highly unlikely scenario, we have a very good solution that is generally not available to other marine mammal researchers. Since we work collaboratively with the Monterey Bay Aquarium, we have the option of admitting the orphaned pup into their surrogacy program. This program allows the pup to be fostered by a captive sea otter mother until it has reached maturity, at which time the pup can be re-released to the wild. The Monterey Bay Aquarium surrogacy program has a long and successful track record for reintroducing stranded or orphaned pups back into the wild. This would be our first and most desired outcome in this unfortunate scenario. If the Monterey Bay Aquarium cannot accommodate the pup (i.e. if there is no room) we can inquire with other captive facilities. If placement for the pup is impossible, the only alternative would be euthanasia.

29. If biological samples are to be collected or received domestically, provide responses to a through j, below, for each individual animal per species. This information, or part of the information, may be provided in table format such as the table below. (Note: if your only proposed activity is to transfer dead marine mammal specimens for purposes of public display or scientific research, complete application Form 3-200-87).

Please refer to Table 1 (in response to question 10(f)).

In addition: All animals captured or sampled under this permit will be wild born. Any specimens collected will be transferred to, and archived at, the Marine Wildlife Veterinary Care and Research Center, Department of Fish and Wildlife, located at Long Marine Lab in Santa Cruz. They may be retrieved from this location for further analysis. The eventual intended use of each type of sample is listed in Table 1. Unused portions of samples will be archived at either the Marine Wildlife Veterinary Care and Research Center (California Department of Fish and Wildlife, located at Long Marine Lab in Santa Cruz) or the Monterey Bay Aquarium, where appropriate -80 freezers (with redundant power back-up) exist. A database is maintained that provides the current disposition of each sample at any point in time.

k. Provide a detailed description of the source of the specimens, including the circumstances under which the animals were/will be taken. For example, this might include the following sources:

The source of all samples will be from live captured wild otters as previously described, or from stranded/dead/beach-cast carcasses. Because of the broad, comparative nature of our research, and the need to obtain representative data from throughout the range (and over all seasons and across years) on all population parameters, sampling may occur at any location within the current range of southern sea otters (Fig 2), or extralimitally if an otter strands outside of the current range, and at any time of year within the time period covered by the permit.

i. Animals stranded alive or dead;
Samples may be obtained from dead, beach-cast sea otter carcasses. These are noted in Table 1.

ii. Animals killed during legal subsistence harvests;
No, subsistence harvest of sea otters does not exist in California

iii. Animals killed incidental to legal commercial fishing operations;
Yes. Unlikely, but an otter carcass that is killed as a result of commercial fishing activities could be sampled. Sometimes the cause of death is not immediately apparent until the samples are taken and the necropsy conducted.

iv. Samples from other authorized researchers or collections;
N/A

v. Soft or hard parts that are sloughed, excreted, or discharged naturally;
N/A

vi. Samples that will be/were intrusively collected from captive-held animals;
N/A. Our samples are from wild animals.

vii. Samples that will /were collected from wild animals.
Yes. As previously described, our samples will be from live-captured wild otter or dead beach-cast carcasses of wild otters.

l. If collecting samples from live animals, describe how the samples were/will be collected, including animal handling and sample collection protocols.
Please refer to Table 1, and the additional information provided in (k), above.

m. For samples received domestically from U.S. permitted researchers, include the researcher's name, affiliation, and permit number under which samples will be/were collected. (Note: if samples are to be imported, you must answer question 12, above).
N/A

30. Provide a list of all personnel that will be involved in the project, identifying each as either a principal investigator or co-investigator, their project duties/responsibilities, and a brief description or CV that demonstrates their experience and expertise to perform their designated duties, including knowledge of the marine mammal species that is/are the subject of this application.

Applicant (Project Lead): Joseph Tomoleoni, Biologist, Sea Otter Project Leader, U. S. Geological Survey, Western Ecological Research Center. Joe's primary interests are in areas of population, behavioral and community ecology. He has worked with sea otters in Alaska, California, and Washington for 10 years and has extensive experience with capture, tagging, and handling of wild otters. Joe is a rebreather diver and has participated in more than 40 sea otter capture events, including as the designated interim project lead for otter re-captures in Santa Barbara, California, in the absence of the previous permit holder, Tim Tinker.

Existing Permittees (Co-Investigators): Brian Hatfield, Michael Kenner, Jack Ames, Michelle Staedler, Daniel Costa, Benjamin Weitzman, Colleen Young, David Jessup (DVM), Michael Murray (DVM), Terrie Williams, James Estes, Mike Harris, James Bodkin, Daniel Monson, George Esslinger, Seth Newsome, Christine Fiorello (DVM), Nancy Anderson (DVM), Lesanna Lahner (DVM), Raymond Wack (DVM), Heather Harris (DVM), Melissa Miller (DVM), and Christine Kreuder-Johnson (DVM).

AMMENDMENT REQUEST: We would like to add the following personnel to our permit. Their CVs are included in this application packet.

<u>M. Tim Tinker:</u> Tim was the previous P.I. and permit holder for this permit. He was also the previous Sea Otter Project Leader for USGS before leaving the service in 2017. We would like Tim to be listed on this permit as a co-investigator, since he is still involved with our research program, just no longer the leader. Tim has over 25 years of experience working with sea otters in California, Alaska, Russia, Washington, and British Columbia, and has participated in countless sea otter capture events, leading most of them.

<u>Zachary Randell:</u> Zach is a graduate student at Oregon State University and a current USGS volunteer. He has participated in sea otter field work and otter captures for the past 5 years and is a skilled rebreather diver and boat operator. Zach is also heavily involved with developing the new smart flipper tags referenced in this application, and will continue to work with our group for the foreseeable future.

<u>Dave Casper</u>: Dr. Casper serves as the Director of Veterinary Services, as well as the attending veterinarian for UCSC's Long Marine Lab and Moss Landing Marine Labs, while also performing services as a contract veterinarian for the Monterey Bay Aquarium. He has more than 30 years of experience working with a variety of marine mammals and other marine megafauna in the field. Dr. Casper has extensive veterinary experience with Southern sea otters, having worked extensively with sea otters for the past 18 years.

31. Describe how you will collaborate or coordinate with other researchers in your study area. Who are they? Explain how this will occur and how it will minimize negative impacts on the species. For example, will it involve sharing resources, samples or data; timing surveys to minimize disturbance, etc.?

Our research program has a long history of collaborating with other researchers in our immediate area, as well as those around the country. Any time we conduct sea otter captures we work directly with the Monterey Bay Aquarium and the California Department of Fish & Wildlife. Descriptions of the roles of our collaborators follow below:

USGS Western Ecological Research Center: The lead agency conducting sea otter research in California. Secures permits and funding, develops proposals for novel research, spearheads the effort to better understand sea otters and their role as keystone predators in nearshore ecosystems. During otter captures, USGS Project Lead serves as the overall leader for capture operations, but makes decisions with senior staff from collaborating agencies and institutions. USGS provides vessel support, divers, boat operators, shore spotters, and general assistance during capture. USGS also provides most of the equipment, including holding boxes other specialized items. The Survey is ultimately responsible for the collection of all data on the project. USGS performs analyses and writes up results for publication in reports and peer-reviewed journals. The findings of these USGS-led studies are useful to the USFWS and a host of other agencies in making management decisions regarding the status and future of Southern sea otters.

Monterey Bay Aquarium: Provides primary veterinary support and expertise, led by veterinarian Dr. Michael Murray. MBA provides animal health care staff including vet techs, and provides access to their state-of-the-art Animal Health Lab, which allows the otters to be processed and cared for in an exceptional facility that would rival any high end hospital in the country. The veterinary team also contributes drugs and medication involved in the work. Additionally, MBA provides leadership and coordination of all shore activities. MBA also provides skilled shore spotters during capture operations, as well as general hands to help transport animals and equipment. MBA occasionally provides some vessel support. The Monterey Bay Aquarium is very involved in the post-release monitoring of study animals, and assists USGS with the primary data collection duties for the duration of each study.

California Department of Fish & Wildlife: Provides staff support in the form of boat drivers, boats, and equipment for sea otter captures. May provide some veterinary assistance. Provides blood processors and the equipment necessary for this task (centrifuges, freezers, etc.). CDFW also provides a Mobile Veterinary Lab for more remote capture operations. Because CDFW employs experience pathologists, they perform the necropsies on most dead sea otters that wash up in California, including all study animals.

In addition to the core collaborators above, we also receive logistical, staff, equipment, and analytical support from various other agencies and institutions, including the United States Fish & Wildlife Service, the USGS Alaska Science Center, the University of California Santa Cruz, the University of California Davis, the University of New Mexico, the Elkhorn Slough National Estuarine Research Reserve, the Santa Barbara Zoo, the Marine Mammal Center, and many others.

32. If you intend to conduct research on animals in a captive-holding facility such as a zoo or aquarium, provide documentation showing that the facility(ies) has authorized you to conduct your proposed activities.

N/A

33. Animal Welfare Act (AWA) Compliance (for research on live animals only): AWA requirements apply to all research facilities, which include institutions, organizations, or people that use or intend to use LIVE animals in research, tests, or experiments; AND, that receive funds under a grant, award, loan, or contract from a department, agency, or instrumentality of the U.S. for the purpose of carrying out research, tests, or experiments, or acquires or transports the animals in commerce. Provide the following documentation:

N/A. We will not be housing any animals for research purposes thus APHIS/AWA registration is not required. We capture and sample sea otters in the wild and release them immediately post-processing.

a. Registration under the AWA as a research facility:
i. Attach a copy of your APHIS certificate of registration as a research facility, or for Federal facilities, a letter from your Institutional Officer that you are compliant with applicable requirements for scientific research under the AWA; OR
ii. If your facility does/will not conduct activities requiring registration under the AWA, attach a letter from APHIS confirming that registration is not required.

N/A. We will not be housing any animals for research purposes thus APHIS/AWA registration is not required. We capture and sample sea otters in the wild and release them immediately post-processing.

b. Institutional Animal Care and Use Committee (IACUC) documentation: If your facility is registered as a research facility under the AWA or is a Federal research facility (see a.i), attach the applicable IACUC documentation from the list in i-iii, below. Please note that all activities that involve an invasive procedure, harm, or materially alter the behavior of an animal under study, even if the activities are carried out in the field, are subject to IACUC review and approval. See (AWA regulations and standards for definition/explanation of covered research activities.):
i. Attach a copy of your final protocols with the IACUC signed approval; OR
ii. Attach a copy of your proposed protocols to be reviewed by your IACUC along with an explanation as to how and when the protocols will be reviewed (Note: A copy of your final signed protocols and certification will be required prior to permit issuance.); OR
iii. Attach the IACUC determination that your research activities are not subject to IACUC review and approval.

Our IACUC approval of our capture and handling SOPs has been granted. Please see attached IACUC approved SOP for sea otter research.

c. If your facility is not registered as a research facility under the AWA, please provide an explanation of how your take activities are reviewed and monitored to assure that the proposed takes are humane (i.e., using the method that involves the least possible degree of pain and suffering).

N/A

Proposals for 3 Current / on-going

PROJECT SUMMARY

Overview:

We propose to test for the hypothesized effects of predator diversity on the stability and resilience of kelp forest ecosystems in the face of an ongoing epidemic that has caused coast-wide losses of key sea star species. We will specifically examine the ability of southern sea otters (Enyhda lutris lutris) to compensate for declines in sea stars and use this opportunity to test hypothesized mechanisms by which predators do or do not collectively contribute to the control of herbivores (purple sea urchins and snails) that can otherwise cause phase shifts in kelp forest ecosystems.

Intellectual Merit :

This project will advance our understanding of the combined roles of species diversity and predators in contributing to the stability and resilience of community structure. Though both predators and diversity have been the focus of numerous studies, fewer have explored how predator diversity does or does not enhance the resilience of marine ecosystems. Specifically, elucidation of both the relative importance of direct (mortality) and indirect (prey behavior) trait-mediated effects of predators on prey density and foraging behavior, while simultaneously identifying the mechanisms (i.e. redundancy, complementarity) by which predator diversity determines the strength of this effect is critical to advancing our understanding of the roles of diversity and predation for ecosystem resilience. Dissecting these complex species interactions with unprecedented controlled field experiments to assess their causal relationships at scales relevant to real patch dynamics, combined with field surveys to evaluate their manifestation at scales of the whole ecosystem (kelp forests) collectively constitute the transformative potential of this research. By exploring these species interactions in kelp forest ecosystems, we capitalize on an extraordinary foundation of ecological understanding, hence the rationale for our focus on this system. In addition, the results of this study will inform our understanding of the ecological consequences and reasons for the extent and duration of ecosystem-wide impacts of the current sea star wasting event.

Broader Impacts :

The broader impacts of this study include three elements: graduate and undergraduate training, public outreach, and informing conservation managers and policy makers. Graduate training will be achieved through co-mentoring one graduate student funded directly by this award. To assist graduate students, faculty and researchers in all aspects of the study, we will recruit from a pool of undergraduates with a substantial portion of underrepresented, largely Latino, students. Our outreach efforts will have three main audiences: K-12, the general public, and marine resource managers. Our outreach efforts will target four unique opportunities. We will collaborate with the Monterey Bay Aquarium to facilitate disseminating information about the study and its results through their extensive outreach program, including a huge K-12 educational program. We will collaborate with UCSC?s Broader Impacts Office to pursue outreach avenues such as The Seymour Marine Discovery Center (http://seymourcenter.ucsc.edu/), which provides a conduit to K-12 programs and general public. We will co-develop a video presentation on the project with the Center?s display team. We will use a website and interactive map maintained by one of our associated investigators for tracking the incidence of sea star wasting. Management and policy institutions whose decisions and actions will benefit from the findings of this project include the United States Fish and Wildlife Service (US FWS), California?s Department of Fish and Wildlife (CDFW) and Ocean Science Trust, and federal agencies including The Monterey Bay National Marine Sanctuary (MBNMS), and the USGS Western Ecological Research Center.

Title: Kelp forest community resilience in action: adaptive responses of predators to a disease-driven food web perturbation

Background

Biological communities and the ecosystems they constitute can be remarkably stable, gradually change through time, or exhibit rapid and dramatic changes between markedly different structural and functional states. Explaining and predicting these dynamics are fundamental goals of ecology with great implications for conservation and management. The capacity to explain and predict system dynamics requires knowledge of the biotic and abiotic processes that determine community structure (i.e. species composition, richness and evenness), and functions (i.e. interactions among species and their environment that determine energy/nutrient dynamics). There are now many examples demonstrating how species interactions can have profound influences on the structure and functioning of marine communities and contribute to their resistance and resilience to biotic (e.g., harvesting, disease, invasion) and abiotic (e.g,, storms, El Nino, habitat loss, hypoxia) perturbations (*1–6*). Collectively, these studies emphasize the separate and substantial effects that higher level predators (*7–24*) and changes in biodiversity (*3, 5, 25–27*), can have on the structure, functioning and stability of marine communities. However, how diversity of key consumers influences the structural and functional attributes and the resistance and resilience of marine ecosystems is less well understood (*17, 28, 29*).

The role of biodiversity and mechanisms by which species and functional diversity imparts resistance and resilience and enhances ecosystem productivity has received great attention (*2–6, 30–38*). Two mechanisms by which diversity enhances these ecosystem attributes are redundancy and complementarity (*39*). Redundancy occurs when species that contribute similar functional roles yet differ in their responses to environmental variation and perturbations, compensate for one another, thereby maintaining ecosystem functionality. Complementarity is the enhancement of one species' function by the presence of other species. Greater species diversity increases the likelihood that both of these mechanisms will be observed within a community, the so-called "sampling effect" (*40*). While these concepts identify mechanisms by which diversity and species interactions contribute to system resistance and resilience, their application for predicting system responses requires knowledge of the relative strengths of species interactions, how species interact and respond to changes in density, and how these interactions vary with different or changing environmental conditions and forms of perturbation (e.g., physical or biological).

Because of their great species richness, productivity and accessibility, kelp forests (laminariales) in temperate oceans throughout the world have attracted ecologists exploring how species interactions influence community and ecosystem dynamics. Kelp forests exhibit a diversity of dynamics, with some forests persisting for decades, others exhibiting strong interannual variability, and others demonstrating rapid shifts from forested to barren states that can persist for decades (*41–59*). Such dynamics also exist within forests, creating mosaics of asynchronous patches in various states of community structure (*41, 43, 44, 46, 55, 60*). These dynamics are thought to reflect the combined effects of physical forces (ocean waves that remove portions or entire forests) and variation in grazing intensity associated with changes in the abundance and foraging behavior of sea urchins (*41, 47, 48, 52, 55, 56, 58, 59, 61–69*) reviewed in (*53, 54, 70, 71*). The persistence of alternative states appears to be influenced by positive feedbacks; overgrazing by urchins both reinforces their intensive grazing behavior (*47, 54, 72*) and facilitates their own recruitment (*73*). In addition, grazing gastropods may contribute to mortality of gametophytes and sporophytes of kelps (*49, 74*).

The vast majority of studies that have examined how species interactions influence the state of kelp forests suggest that specific higher-level predators can have marked influences on forest

dynamics (reviewed by (*54, 71, 75*). For example, studies of sea otters, *Enhydra lutris*, in kelp forests along the Aleutian archipelago (*76–80*) and Vancouver Island, Canada (*58*) revealed how trophic cascades generated by these apex predators can control the structure of these forest communities. When otter densities were reduced through human exploitation or orca predation, otters were unable to control the behavior and abundance of their prey, herbivorous urchins, allowing these systems to shift from forested to barren reefs (devoid of macroalgae) (Estes et al 1998). At smaller spatial scales, patchy distribution of the sunflower star, *Pycnopodia helianthoides*, in Alaskan forests create mosaics of forested and barren reef patches altering the structure and productivity of the system (*81*). California sheephead, *Semicossyphus pulcher*, are urchin predators in *Macrocystis* forests along the coasts of southern California and Mexico (*69, 82–85*) and urchin density, size structure and foraging rates can be inversely related to sheephead density (*69, 83, 85, 86*). Large size classes of spiny lobster can likewise control the density and size structure of urchins in *Macrocystis* forests of Tasmania. Where the size structure of lobster is reduced by commercial fishing, urchins achieve size refuge and forests are replaced by barrens (*87*). Similarly, in *Macrocystis* forests in southern California, the California spiny lobster (*Panuliris interruptus*) can be an important predator on purple and red sea urchins (*51, 82, 88, 89*), though their effects appear to vary geographically (*90, 91*). The extent to which the cascading effects of any one of these urchin predators determine the spatial and temporal variation in kelp abundance continues to be debated among ecologists. While these studies suggest the importance of individual predators in determining the dynamics, structure and functions of kelp forests, they also implicitly assume that loss of these species are not compensated for by alternate (functionally redundant) predators. Thus, while such predators are particularly vulnerable to natural and anthropogenic losses, the consequences of predator diversity in controlling grazing effects and contributing to the resistance and resilience of forest ecosystems remains poorly understood (*29*).

Predator diversity can influence the strength and direction of species interactions, including trophic cascades, by either dampening (*92*) or magnifying (*93*) their effects. For example, Byrnes et al (*93*) found that diversity (not density) of predators at lower trophic levels was negatively correlated with herbivore abundance and positively correlated with kelp abundance. These results were corroborated by mesocosm experiments and also revealed that predator effects involved behavioral responses of prey that dramatically altered their grazing rates. That study and others (*47, 83, 86, 94, 95*) lend evidence for strong indirect trait-mediated effects of predators in altering the distribution and foraging behavior of urchins and contributing to resistance and resilience of kelp forests. Indeed, the role of trait-mediated (especially behavioral) influences of predators may be a particularly important mechanism of trophic cascades (*96, 97*). As such, and contrary to the majority of studies indicating the importance of particular predators, predator diversity may enhance the effect of each predator species in controlling grazers, because a more diverse suite of predators feeds more efficiently across all size classes of urchins (i.e. complementarity) or one predator can compensate for the loss of another (i.e. redundancy). Both of these mechanisms may involve direct (mortality) or indirect (foraging behavior) responses of their prey (urchins).

In central California, southern sea otters (*Enhydra lutris nereis*, hereafter "otters") are important predators of sea urchins (*98, 99*) and the almost ubiquitous low densities of urchins in this area is assumed to reflect their presence (*59, 98, 100*). Otters are voracious predators that consume 25-33 percent of their body weight per day (*101*) and whose diet includes urchins as well as a diverse array of benthic invertebrates (*98, 102*). Although diet diversity is high at the population-level, individual otters in resource-limited areas tend to specialize on a just few prey types (*99, 103*), and so urchins (when they are at low abundance) are mostly consumed by urchin specialists.

However, examples of marked changes in urchin abundance independent of otters also exist (*61, 62, 104*), and otter access to local (patch-scale) populations of urchins has never been manipulated to evaluate the rate and magnitude of mortality attributable to their predation. Another potentially important urchin predator in the central coast, the sunflower star (*Pycnopodia helianthoides*, hereafter *Pycnopodia*) feeds on smaller sea urchins and a diversity of herbivorous gastropods (e.g., *Promartynia pulligo*, hereafter *Promartynia* or snails) (*62, 63, 81, 82, 93, 105*). Another particularly abundant carnivorous sea star, the giant sea star (*Pisaster giganteus*, hereafter *Pisaster*) forages on sessile and mobile invertebrates, including a diversity of carnivorous and herbivorous gastropods (*74, 106, 107*). However, over 1000 diet samples of *Pisaster* produced zero urchins (*108*), suggesting that influences of *Pisaster* on urchin foraging rates is more likely to be a predator avoidance response. Thus, understanding the separate and combined (additive or multiplicative) effects of these sea stars and otters in controlling urchin density and foraging behavior is central to understanding how predator diversity affects the resistance, resilience and productivity of kelp forest ecosystems.

In 2014, several species of intertidal and shallow subtidal sea stars experienced an epizootic (viral or bacterial disease) that has led to widespread declines in the abundance of several species of sea stars (*109*). Across the West Coast of North America from Alaska to Mexico, populations of intertidal (*Pisaster ochraceus*) and subtidal (especially *Pycnopodia* and *Pisaster giganteus*) sea stars have experienced local extinctions, including those species previously implicated as "keystone" predators that disproportionately influence the structure and functions of their ecosystems relative to their abundance (*81, 110, 111*). Already, densities of both purple, (*Strongylocentrotus purpuratus*, hereafter "purple urchins"), and red urchins (*S. franciscanus*, hereafter "red urchins"), have increased beyond typical densities (Figure

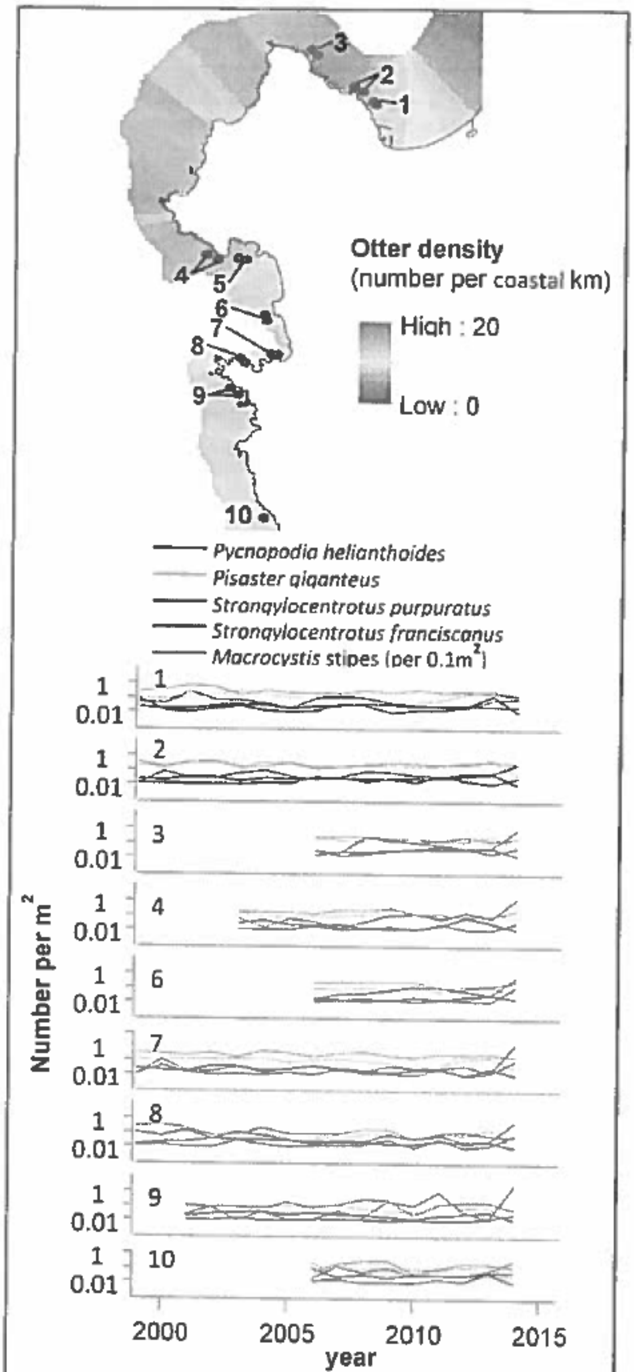


Figure 1. Otter densities and temporal patterns of sea star (*Pycnopodia helianthoides* and *Pisaster giganteus*), sea urchins (*Strongylocentrotus franciscanus* and *S. purpuratus*) and giant kelp (*Macrocystis*) stipes from sites surrounding the Monterey Peninsula during the period 1999-2014. Density estimates represent mean of 6-12 transects per site.

1). Over the 16 years and 10 sites surveyed around the Monterey Peninsula, annual change in density (log ratio of one year to the next) of purple urchins was inversely related to change in *Pisaster* and *Pycnopodia* (R^2=0.1144, P<0.0001 and R^2=0.0852, P<0.0001, respectively). In contrast, a weak relationship was detected between annual changes in density of red urchins and *Pisaster* (R^2=0.0313, P= 0.0303), and no relationship was detected between red urchins and *Pycnopodia* (R^2=0.0038 , P= 0.4529).

Although densities of giant kelp, *Macrocystis pyrifera,* have not yet decreased as predicted by the trophic cascades identified in the many examples summarized above (Figure 1), the occurrence of patchy barrens, rarely seen over the 15 year history of surveys conducted throughout central California kelp forests, have been noted (personal observations). Based on these observations and expected time lags in the dynamics of both urchins and kelps to declines in sea star predators, marked declines in kelp density and shifts from forested to barren reefs are predicted. As such, the current sea star epizootic presents a very unique and timely opportunity to explore whether and how the diversity of key urchin predators may buffer ecosystems to this perturbation.

Initial increases in recorded numbers of red and especially purple urchins across all size classes suggest that the apparent increase in densities reflect a trait-mediated behavioral response. As observed in the several studies described above, increases in densities of larger size classes implicate a shift in urchin behavior that has led to their greater detection on surveys (Figure 2). Rapid increases in the larger size classes of purple urchins observed in 2014 can't be explained by numerical responses (i.e. recruitment) or increased survivorship; numbers of larger purple urchins observed in 2014 exceed the sum of the that size class (100% survivorship) and then next three smaller size classes from the previous year (typical mean growth rates of purple urchins are roughly 1-3 cm per year in central California; (*62, 112, 113*). In contrast, increases in the smallest (3 cm) size classes may reflect combined numerical (recruitment from smaller size classes) and behavioral responses. The observed increases in densities across all size classes of purple urchins suggest (i) responses to observed declines in sea star predators, and (ii) that significant levels of compensatory predation by otters on purple urchins have yet to be realized.

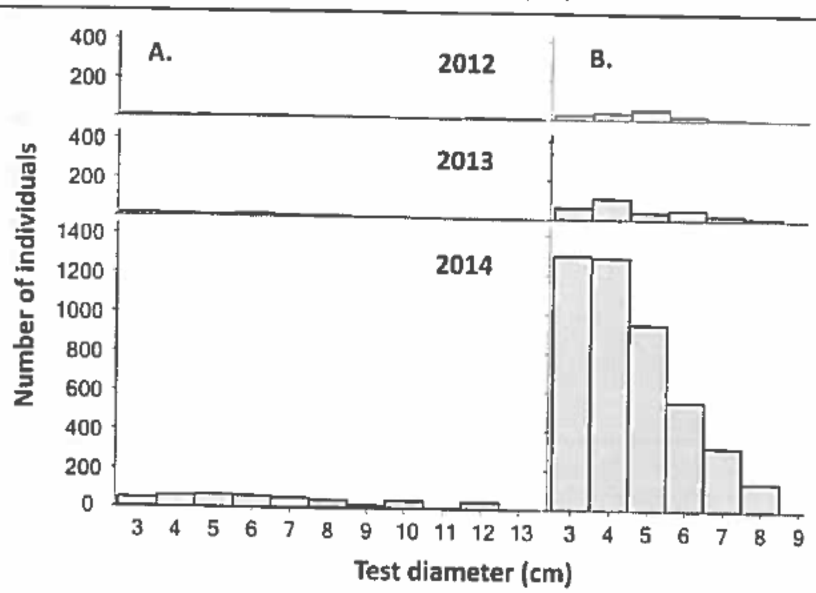


Figure 2. Size frequency distribution of (a) red sea urchins and (b) purple sea urchins observed on survey transects at sites identified in Figure 1 over the period 2012-2014.

Therefore, we propose to test several general hypotheses germane to the questions of whether

and how predator diversity (i.e. the presence of alternative predators) may buffer communities and ecosystems to perturbations. We draw from the ongoing biotic perturbation (epizootic) that has led to dramatic declines in populations of sea stars and explore the potential role of otters to buffer population responses of urchins that may otherwise lead to dramatic shifts in the structure and functions of kelp forest ecosystems in Central California.

Proposed Research to be Undertaken

Given this background, in this study we will address the following eight questions. Questions one through four will be addressed using experimental orthogonal manipulations of predators (otters, *Pisaster, Pycnopodia*) to observe the response of prey (purple urchins, *Promartynia*), and algae (*Macrocystis*). Question five will be addressed using kelp forest ecosystem surveys, and questions six through eight will be addressed using radio-tagging and observation of otters.

1) Predator effects on density and size of exposed prey. What are the separate and combined effects of otters and *Pisaster* or *Pycnopodia* on the density and size structure of *exposed* (i) purple urchins, (ii) *Promartynia* snails and (iii) young *Macrocystis* plants? *Exposed* urchins and snails are those not confined to crevices, reflecting active grazing and vulnerability to predation. Counts of exposed individuals in the orthogonal predator manipulations will indicate combined direct (mortality) and indirect trait-mediated (behavioral) predator effects.

2) Direct and trait-mediated effects of predators. What are the relative contributions of mortality (density effects) and behavioral responses (trait-mediated effects) to changes in the density of *exposed* urchins in response to the presence of predators (otters, *Pisaster* or *Pycnopodia*)? Evidence suggests that urchin responses to *Pisaster* are largely behavioral (not direct mortality) whereas responses to *Pycnopodia* and otters include both urchin mortality and behavior. These will be teased apart by distinguishing changes in density and size structure of exposed versus total urchins and snails in the orthogonal predator manipulations.

3) Redundant versus complementary predator effects. Do the different predators (otters, *Pisaster* and *Pycnopodia*) contribute differentially to reduced numbers of exposed prey (purple urchins and snails) of different size classes, reflecting complementarity among these predators across the size distribution of urchins and *Promartynia*? Because otters feed solely on larger size classes of urchins, control of urchin populations might be a function of sea star predation on smaller size classes and otter predation in larger size classes. This will be tested by comparing size frequency distributions of surviving urchins across the orthogonal manipulations of predator access, and combining these data with observational data on size-dependent consumption rates by tagged otters.

4) Cascading predator effects on kelp. Are the separate and combined effects of predators (otters, *Pisaster* and *Pycnopodia)* on the density and size structure of *exposed* purple urchins (based on combined numeric and trait-mediated responses) manifest in changes in mortality rate and density of young *Macrocystis* plants, reflecting a trophic cascade?

5) Larger scale manifestation of predator effects. Are the direction, strengths and mechanisms (mortality versus behavior) of predator-prey interactions, including the hypothesized three-level trophic interaction revealed in the controlled orthogonal experiment, manifest over time and among sites distributed across the study region? To test hypothesized spatial and temporal correlations in density and size structure) of prey (urchins, *snails*) and kelp (*Macrocystis* and other macroalgae) to variation in predator density (otter, *Pisaster, Pycnopodia*), we will conduct annual surveys across ten sites distributed across the study region. These results will indicate whether conclusions generated by the experiments (i) "scale-up" to explain variation in the structure and dynamics among kelp forests along the coast, and (ii) are robust to the environmental (reef structure, oceanography) and biotic (overall community structure) variation in these kelp forest ecosystems.

6) Sea otter behavioral responses. Does the rate of predation on and relative contribution of purple urchins and *Promartynia* in the diet of otters increase in response to declines in sea

star densities and increases in density of urchins and snails, as compared to "normal" variation in dietary prevalence over the past 15 years?

7) Co-variation of predators and prey. Is there spatial variation in the dietary response of sea (rate and success) and does this correspond to spatial variation in prey density (exposed urchins and *Promartynia*)?

8) Effect of individual specialization. Do spatial and dietary response vary predictably among individual otters based on historic and current patterns of dietary specialization? That is, does increased dietary prevalence of urchins and/or snails occur similarly for all otters, or is it only evident (or most pronounced) for urchin/snail diet specialists?

Approach:
We propose to answer the questions posed above with a combination of field experiments, ecosystem surveys, and telemetry-based studies. These methods will enable us to examine the consequences of reduced rates of sea star predation on urchins at two spatial scales. Experimental manipulations will identify causal effects of relative rates of predation at the scales of ($6m^2$) patches. Surveys conducted at ten sites over three years will identify spatial and temporal correlations among sea star, otter and giant kelp densities across natural variation in densities of these species as well as environmental conditions (reef structure, wave exposure). Observational data collected from radio-tagged otters will provide longitudinal information on variation in otter diets both at the population and individual level. Surveys and otter observations will evaluate the extent to which causal responses identified at the patch scale do or do not scale up to site level.

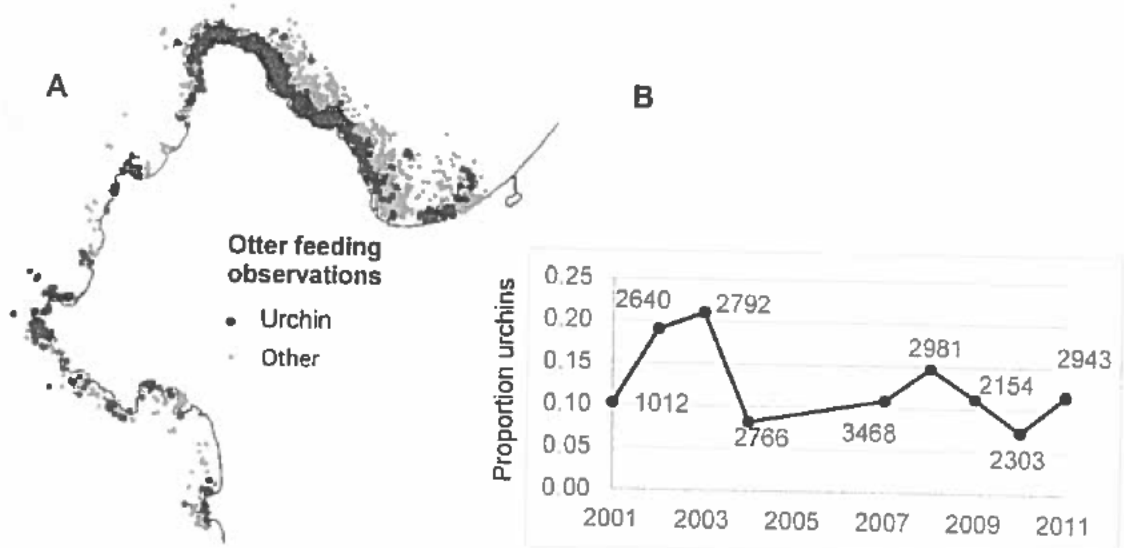


Figure 3 (A) Distribution of sea otter foraging activity: purple points indicate observations of otters feeding on urchins. B) Proportion of total feeding observations in which otters fed on urchins in the study region. Values indicate sample size (number of observations).

Orthogonal manipulation of urchin and snails predators
We propose to deploy 24 $6m^2$ cages designed to orthogonally manipulate the access of otters with access of either *Pisaster* or *Pycnopodia* to a size range of purple urchins and *Promartynia*. Orthogonal manipulations of otters and *Pisaster*, and otters and *Pycnopodia* will be conducted separately in year 1 and year 2 of the project, respectively. Depending on the rate of responses of predators and prey, Year 3 is a buffer for each of these experiments. Otherwise, a third

experiment orthogonally manipulating the two sea star species or prey (urchin) density refuge availability will be conducted.

Cage design: All 24 cages will be deployed at a depth of 10-12 m along a section of the northwest face of the Monterey peninsula where a history of otter foraging rates and behavior have been collected (Figures 1 and 3). Cages are 2m by 3m ($6m^2$) rectangles of 0.75 m height (Figure 4). The mesh is standard 11.5 gauge galvanized metal cyclone fencing (5cm x 5cm square mesh) and the structural supports are standard 4cm diameter galvanized steel cyclone fencing posts and three-way joints. All 24 cages have cyclone fencing walls, a cyclone fencing bottom and 10cm horizontal lips. The bottom, walls and lips of all 24 cages are lined with 1 cm sq galvanized mesh (hardware cloth) to prevent prey (urchins and snails) and sea stars from entering or leaving the cages. This allows us to control prey and sea star densities over the duration of the experiments. The 12 cages designed to exclude otters have two panels of cyclone fencing that enclose the top and are removable to allow divers to survey exposed urchins and snails. Top panels are secured to the horizontal supports at the top of the walls by heavy duty (1cm wide) plastic cable ties. The 12 cages designed to allow access of otters have no top. Horizontal lips at the top of the vertical walls are designed to prevent sea stars, urchins and snails from entering or leaving the cages, but tips of these horizontal lips may be painted with copper-base paint if necessary.

Reef habitat: To weight cages to the bottom and to standardize heterogeneity of the reef structure (i.e. visual detection of exposed prey and availability structural refuge for prey) rock boulders will be placed inside the cages. Size frequency (diameter) and shape of boulders will be similar across all 24 cages. The amount of rock habitat across all cages will be similarly adjusted to ensure sufficient structural refuge for the number of prey in each cage. This is required for the assessment of behavioral versus density responses to predator treatments (Question 2).

Spatial design: Six replicate cages of four orthogonal treatment levels (- otters -star; -otter +star; +otter -star; +otter, +star) will be spatially blocked with random placement of each treatment level per block. The design assumes that otters will access the two "otter accessible" treatment levels, based on the perceived influence of otters on urchin densities in the study region, the large number of otter-urchin feeding observations at the experimental site (Figure 3) and the relatively large area (6 m^2) of the cages. To test this assumption, a time lapse video recorder (GoPro) will be deployed at each block of four cages to monitor the frequency of otter access. Cages will be separated by a minimum of 5m to reduce the likelihood that predators will influence the behavior of prey in adjacent cages.

Prey manipulations: Natural densities and size structure of purple urchins and *Promartynia* snails will be established within cages at the onset of each experiment. Urchin dispersion is extremely patchy and our past surveys in the study region have detected upper densities of 15 per m^2 (= 90 per $6m^2$ cage). Size frequency distributions of purple urchins are extremely variable, but using the distribution depicted in Figure 2 and making no size class less than 10 individuals, we will stock each cage with 22 3cm, 22 4cm, 16 5cm, 10 6cm, 10 7cm, and 10 8cm test diameter purple urchins. Watanabe (*74*) estimated mean density of adult *Promartynia* at 4 per m^2 and 40 per m^2 on rock bottom and kelp, respectively, and juvenile (< 16mm dia) *Promartynia* at 3 per m^2 and 227 per m^2 on rock and shell rubble habitat, respectively, at 12 m depth in southern Monterey Bay. Given this great variability, we will seed each cage with 60 *Promartynia*, allocated across three size classes: 30, 20 and 10 individuals in 1±0.5, 2±0.5 and 3±0.5 cm basal diameter. These size distributions of both urchins and snails reflect variation in natural size structure, to better mimic effects of encounter rates on a predator's size selection,

but also increase numbers of larger size classes to characterize the observed changes in size distributions described above and avoid proportional inflation of loss of few individuals. Prey will

be placed in cages and cages will be covered with top panels for a 24 hrs acclimation period prior to adding or allowing access of predators. Using techniques described in Pearse and Pearse (*112*), all purple urchins added to cages will be treated with injections of tetracycline to mark the initial diameters of their tests. This will allow us to identify growth of individuals and immigrants to the cages by collecting and sampling all individuals at the end of the experimental trials.

Effect of grazer density and behavior on kelp survival: To determine the effect of changes in urchin and snail density and behavior on the survival and size structure of *Macrocystis*, we will add similar size rocks containing young *Macrocystis* plants to every cage. Reed and Foster (1984) recorded 9.6± 1.4 young *Macrocystis* recruits per m^2 in a forest on the Monterey peninsula. Recruitment is very patchily distributed, so we will distribute 10 (0.25m dia) rocks with six small (single stipe, 5-10cm height) *Macrocystis* plants each (total 60 plants) per cage. Rocks with young *Macrocystis* recruits are abundant at the proposed experimental site.

Sampling: One block of four cages will be sampled each day (all four blocks each week) for the duration of the study. Each sample, the number of exposed urchins and *Promartynia* will be counted and measured. Depending on the rate of change of treatment levels exposed to

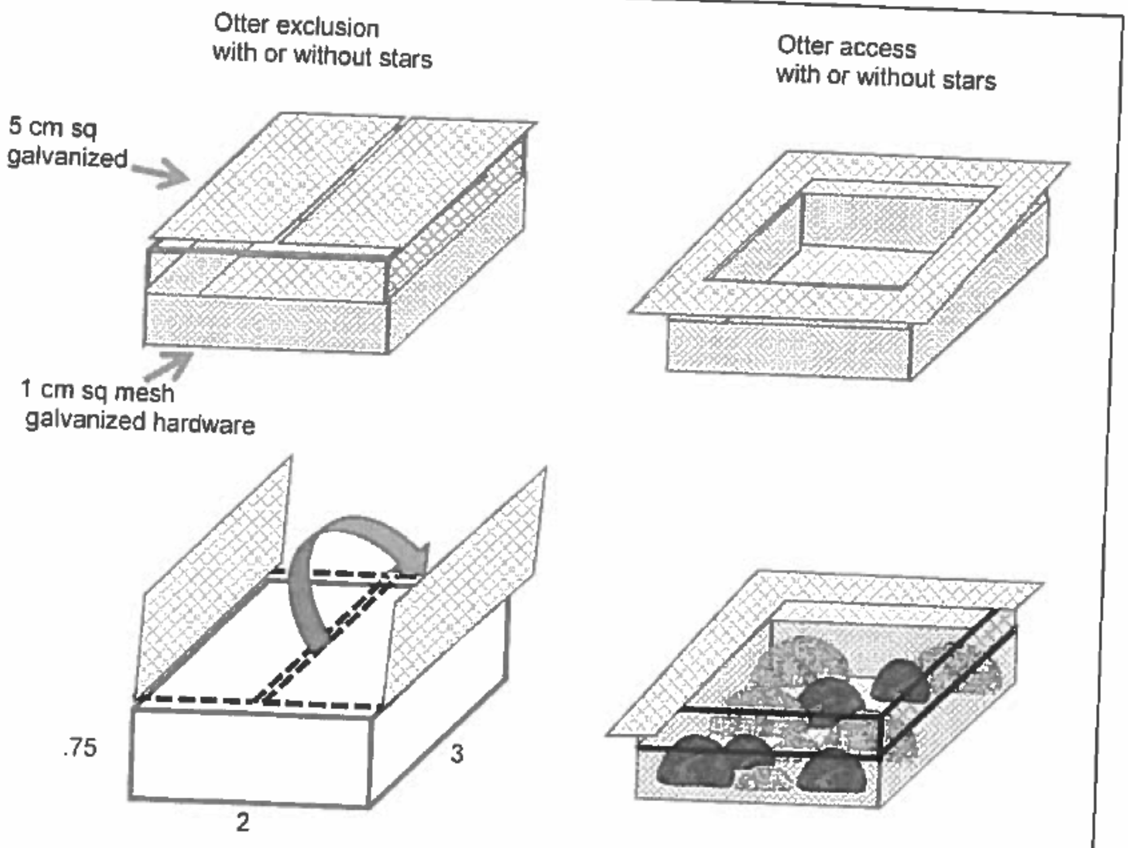


Figure 4. Predator exclusion/inclusion cages designed to (a) exclude sea otters with or without sea stars, or (b) allow access by sea otters with or without sea stars. Horizontal lips atop walls of otter accessible cages impede urchins, snails and stars from migrating in or out of cages. (c) Removable panels on otter exclusion cages allow divers to count and measure exposed and hidden sea urchins, snails and kelp. (d) Rocks are placed inside cages to standardize visual detection and refuge for prey, including rocks with young kelp.

predators, a total count of individuals (exposed and hidden) will be made at a frequency of two weeks (every other survey) to estimate the trajectory of the relative abundance of exposed and hidden individuals. More frequent estimates of total individuals will be made if declines in number of exposed individuals are rapid, less frequent if the decline is slow. The lower frequency of estimates of total number is to minimize the disturbance of searching for hidden individuals during the experiment. The number and height of each *Macrocystis* plant will be recorded on each survey.

Tests of hypotheses:

1) Predator effects on density and size of exposed prey. Density (number per cage) responses of exposed urchins, snails and kelp plants will be estimated as both the (i) slope of the decline in numbers per cage recorded weekly over the duration of the experiment, and (ii) comparison of final numbers of exposed individuals among treatment levels at the end of the experiment. The relative **separate** effects of predators are determined by comparing prey declines in each single-predator with no-predator treatment levels and comparing these differences between predators. Rates of decline and final densities will be compared among treatment levels with general linear model approaches (e. g., analyses of covariance – ANCOVA and ANOVA, respectively), assuming parametric assumptions are met. If not, we'll use a generalized approach. The **combined** effects are determined by comparing rates of decline and final densities observed in single-predator and two-predator treatments. The interaction term in these comparisons will be used to test for non-additive effects of predators. Signification interactions between pairs of predators may be positive (facilitated rates of predator foraging efficiency) or negative (interference between predators) (*114*, *115*). Separate and combined effects of predators on prey size structure will be tested similarly by comparing prey size distributions between no-predator, single-predator, and two-predator treatments. Differences in size distributions will be tested among the weekly samples and at the end of the experiment using a generalized linear model with a log-linear function. Comparison of changes in size structure over time between predator treatments indicates the relative predation rates on different size classes of prey. These differences will be evaluated by decomposing the model to test for the interactions among size (binned into the classes described above), time (weeks), and predator treatment levels. We predict differences in effects of predators based on their known selective foraging (e.g., otters on the largest size classes versus *Pycnopodia* on smaller size classes) and direct versus indirect effects (e.g., behavioral responses to *Pisaster* are likely to be greater for smaller urchins and more uniform across all size classes of snails).

2) Direct and trait-mediated effects of predators. Evidence suggests that urchin responses to *Pisaster* are largely behavioral (not direct mortality) whereas responses to *Pycnopodia* and otters include both mortality and behavioral responses. These will be teased apart by distinguishing changes in density of exposed versus total (exposed plus hidden) urchins and snails in the orthogonal predator manipulations. To avoid nonlinear responses due to limited refuge availability, we will determine that sufficient refuge is available for all prey at the beginning of the experiment, by using crushed urchins to elicit a refuge-seeking response and searching for any remaining exposed individuals. Crushed conspecifics elicit a very strong refuge seeking behavior in urchins (*58*). To test the hypothesis of differences in the relative contribution of direct density effects (mortality) and behavioral responses of exposed prey among the three predators, we will compare the relative rates of change in exposed vs. total prey among the four treatment levels. For example, we predict that any change in the relative frequency of exposed urchins over time would be attributed almost entirely to behavioral responses and little, if any, to mortality. Hence, the (negative) slope of exposed urchins over time would be significantly greater and different than the change in total number (i.e. time by response interaction). Because *Pycnopodia* would be an ever-present voracious predator of urchins and snails, we predict a significant decline in both exposed and total density, though the (negative) slope of decline in exposed individuals should still be greater than total number

because of a refuge effect. Because otter predation is episodic and possibly more thorough (turning of rocks) the rate of decline in total numbers and exposed numbers will be more similar to one another. These responses may well be non-linear. Generalized linear models (GLM) will be used to compare slopes between behavioral and density responses, between prey (urchins and snails) and between predators to evaluate how the relative strengths (contributions) of the behavioral and density effects vary by species of prey and predator.

3) **Redundant versus complementary predator effects.** Because otters feed solely on larger size classes of urchins, control of urchin populations might be a function of sea star predation on smaller size classes and otter predation in larger size classes. This will be tested by comparing size frequency distributions of surviving urchins across the orthogonal manipulations of predator access. As described in Question (1), differences in size distributions will be tested among the weekly samples and at the end of the experiment using a generalized linear model with a log-linear link function. Comparison of changes in size structure over time between predator treatments indicates the relative rates at which they influence the different size classes of prey. These differences will be evaluated by decomposing the model to test for the interactions among size (binned into the classes described above), time (weeks), and predator treatments to determine if the combined effects of both predators are additive or multiplicative on each size class.

4) **Cascading predator effects on kelp.** The cascading effect of predator control of grazer density and behavior is manifest in the survival and size of the foundational species, *Macrocystis*. Change in kelp density from those established at the onset of the experiment will be compared among the four predator treatment levels with general linear model approaches, assuming parametric assumptions are met, or generalized linear model, as described for Question (1). Differences in size distributions will be tested among the weekly samples and at the end of the experiment using a GLM with a log-linear link function. Comparison of changes in size structure over time between predator treatments indicates the relative rates at which they influence the different size classes of kelp. These differences will be evaluated by decomposing the model to test for the interactions among size (measured to the centimeter and binned into size classes depending on growth rate), time (weeks), and predator treatment levels. We predict that declines in kelp density will be greatest in cages excluding all predators, and least likely in the presence of both otters and *Pycnopodia*. Intermediate reductions may occur in the presence of *Pisaster*, however as in all cases of combined predator treatments, this depends on whether predator interactions are positive (facilitated rates of predator foraging efficiency) or negative (interference between predators).

5) **Larger scale manifestation of predator effects.** To test hypothesized spatial and temporal correlations in density and size structure (generated from the experiment) in prey (purple and red urchins, snails) and kelp (*Macrocystis* and other macroalgae) to variation in predator density (otter, *Pisaster*, *Pycnopodia*), we will conduct the annual surveys described below across 10 sites distributed across the study region.

Community surveys

We will conduct kelp forest community surveys at ten sites distributed throughout the Monterey Peninsula study region in order to (1) characterize the progression of predator (*Pisaster* and *Pycnopodia*), grazer (purple and red urchins, *Promartynia* and other herbivorous and detritivorous gastropods) and algae (*Macrocystis*, other kelps and foliose red algae) population dynamics, and (2) determine whether species interactions revealed in the caging experiment are manifest at the larger spatial scale of forests and the greater natural variability of environmental (biological and physical) conditions among forests. Survey sites include those for which we have a long-term (9-16 year) baseline characterization of community structure prior to at and at the onset of the sea star wasting epidemic (Figure 1). These sites also include baseline characterizations of otter density and foraging behavior (see below). At a subset of these sites, continued otter surveys will allow us to (3) determine how otter distribution and

foraging behavior respond to changes in prey (urchin and snails) and alternative predator (*Pisaster* and *Pycnopodia*) densities estimated by the benthic community surveys.

Each survey "site" is comprised of two halves side by side along the shoreline, in which two 30m long x 2m wide swaths are located along each of three isobaths (5m, 12.5m and 20m depth) from the inshore to the offshore width of the forest. Surveys will be conducted annually (July-early September) at each site in each year of the study period. Details of species lists and sampling protocols are available at http://www.piscoweb.org/research/science-by-discipline/ecosystem-monitoring/kelp-forest-monitoring/subtidal-sampling-protoco.Generally, on each of the twelve $60m^2$ transects, densities of conspicuous (> 2.5cm dia) size classes of common invertebrates are recorded. Size frequencies of urchins and sea stars are recorded in the same categories described in the experiment. Densities of juvenile (> 1m height) and adults of the two canopy-forming (*Macrocystis* and *Nereocystis*) kelps, subcanopy-forming stipitate (> 30 cm height) kelps, and prostrate (> 10cm blade width) kelps and erect (> 6cm height) fucoids (e.g., *Cystoseira*) are recorded. Stratified subsampling is used to estimate densities of particularly abundant species such as urchins and snails. The distance along the transect in which the first 30 individuals are counted is recorded and this is repeated for each of three 10m subsections of the transect.

Uniform point contact is sampled (30 points at 1m intervals) to estimate percent cover of five morphological categories of foliose red algae, erect and encrusting coralline algae, and species of brown algae (e.g., Dictyotales). Percent cover of colonial or aggregating invertebrates are recorded at higher phyletic levels of taxonomic resolution (e.g., bryozoan, sponge, tunicate). Percent cover is also used to characterize the relative abundance of structural features of the rocky reef, including substratum type (sand, cobble, boulder, bedrock) and relief (0-10cm, 10cm-1m, 1m-2m, > 2m).

We will continue to follow urchin density and size-structure to track the progression of size classes, including recruitment and survivorship of the successful recruitment class seen in 2014. We will also record whether each individual urchin is exposed versus sheltered to estimate change in the proportion of exposed individuals. This will allow us to quantify the magnitude of the behavioral and possible demographic response to the decline of sea stars and how these correlate with spatial and temporal variation in combinations of relative densities of predators (otters, *Pisaster* and *Pycnopodia*).

We will test for temporal and spatial relationships between univariate (e.g., individual predator densities) and multivariate (e.g., relative abundances of predators) independent variables and univariate response variables (e.g., proportion of urchins exposed, urchin density, kelp density) and multivariate response variables (e.g., combinations of urchin and kelp densities). We will use ordinary least squares regression for these analyses, testing for spatial autocorrelation in residuals and, if significant, using geographically weighted regression analysis (*116*) to correct for bias.

6) Sea otter behavioral responses. To address the question of how sea otters have or have not responded to the sea star decline at larger scales, we will initiate a telemetry-based study of tagged otters, sampled randomly from within the study area, from which we will collect observational data on otter diets for comparison with equivalent data collected over the past 15 years in the same area (Figure 3; (*99*, *103*)).

Sea otter tagging, monitoring and data collection

We will capture and tag a sample of approximately 25 otters from the study area (north and west side of Monterey peninsula) following methods we have utilized for many previous studies in this area (*99*, *117*). All methods described below are covered under current Federal permits to T. Tinker and authorized by the UC Santa Cruz Institutional Animal Care and Use Committee (IACUC). Captures are conducted by a highly experienced and uniquely trained sea otter

capture team using closed-circuit SCUBA methods, underwater propulsion devices and specialized "wilson traps" (*118*). Captured animals are transported to the Monterey Bay Aquarium (MBA) for processing by an experienced veterinary team: animals are anaesthetized, tagged, and receive comprehensive health exams and bio-sampling. Anaesthetization follows well established protocols (*119*), and once unconscious each animal is equipped with color-coded flipper tags for visual identification and a surgically implanted VHF transmitter for radio telemetry tracking. Samples collected include blood (used for screening a standardized series of blood parameters, to evaluate health and contaminant/disease exposure), saliva and fur (for stress hormone analyses), and vibrissae which are used to evaluate long-term individual diets via stable isotope analysis (*120, 121*). Participants in the capture/tagging phase include scuba divers and boat operators from UC Santa Cruz, USGS and California Department of Fish and Wildlife (CDFW), and veterinarians and staff from MBA.

After release, study animals are monitored regularly (using standardized VHF telemetry protocols: (*117*)) over the subsequent 3-year period corresponding to the transmitter battery life. Field personnel conduct shore-based daily surveys of the study site using standard telemetric protocols to locate all study animals (triangulation on radio signal using VHF telemetry receivers and visual identification using 50-80X Questar spotting scopes) and record precise GPS position, survival, reproductive status and instantaneous behavior. Attempts will be made to re-sight all study animals at least 5 times per week. Individual study animals are then selected haphazardly (subject to appropriate behavior and visual conditions) for collection of observational data on diet and feeding behavior, following well-established protocols (*99, 102, 122, 123*). Briefly, the otter is observed using 50-80X spotting scopes (Questar Inc., Isanti, MN) over a contiguous sequence of 20 - 60 dives, referred to as a foraging bout. Information recorded includes date and time, precise location of each dive (determined by visual triangulation using GPS, compass and laser range-finder), duration of the subsurface dive interval (" DT") and the post-dive surface interval ("ST") for each feeding dive (in seconds), outcome of each dive (i.e. whether or not prey was captured), species of prey captured, number and size of prey items, per-item handling time (number of seconds required to handle and consume each item), whether or not tools were used to handle the prey, and ambient conditions (including sea-state, wind, etc.). Prey size is recorded as the estimated diameter of the shell or maximum body dimension (excluding appendages), categorized into 2.5 cm size-classes. For observations where prey cannot be reliably identified to species, the items in question are assigned to the lowest possible taxonomic unit. Any items that cannot be reliably categorized to any taxonomic level are listed as "unidentified". Additional information recorded by observers includes numbers of prey items that were stolen by or from the focal animal and, in the case of females with dependent pups, the number of items that were shared with the pups. Data are then analyzed to estimate prey-specific consumption rates, using a resampling procedure that uses Monte Carlo simulations to account for missing data parameters and adjust for sampling bias (see Tinker et al 2012, 2015).

We will attempt to collect 500-1000 dives per study animal over a 3 year period, augmented by an additional 5000 dives from randomly selected untagged otters in the same area, for a total sample size of ~15,000 recorded feeding dives. We will estimate the per-capita rate of predation on urchins and marine snails, and compare these with estimates available for 1999-2014 (for which we have an existing data set of over 60,000 recorded dives). We will used mixed-effects linear models (with individual otter treated as a random effect) to test for temporal trends in prey consumption rates.

7) Co-variation of predators and prey. To address this question, we will combine spatially-explicit data on prey consumption by otters (see above; Figure 3) with site-specific data on urchin and snail abundance from subtidal surveys. We will test for a relationship between prey abundance and otter consumption rates using ordinary least squares regression analysis. We

will test for spatial autocorrelation in residuals and, if significant, use geographically weighted regression analysis (*116*) to correct for bias.

8) Effect of Individual Specialization. Based on previously published analyses of otter diets around Monterey peninsula, we know that individual otters tend to specialize on a small suite of prey, such that the high diet diversity occurring at the population level is actually an emergent phenomenon reflecting the diversification of specialized diets among individuals (*99, 102, 103, 120, 121*). We might therefore expect that those otters specializing on a diet high in urchins or snails would show the earliest and most significant response to the increase in urchins and snails resulting from the local extinction of sea stars. This hypothesis implies an enhanced degree of individual specialization. An alternative hypothesis is that all otters will respond similarly to the "windfall" created by the sudden glut of urchins, a pattern that would imply a relaxation of individual specialization as all individual diets became more similar. To test these predictions, we will compare the degree of individual specialization in our current sample of tagged otters to that observed over the period 1999-2014. We will use diet similarity indices (*124*) to compare diets among individuals and to quantify the level of specialization for each study group.

Intellectual Merit

This project will advance our understanding of the combined roles of species diversity and predators in contributing to the stability and resilience of community structure. Though both of these elements of community structure have been the focus of numerous studies, fewer have explored how predator diversity does or does not enhance the resilience of marine ecosystems in field experiments. Specifically, elucidation of both the relative importance of direct (mortality) and indirect (prey behavior) trait-mediated effects of predators on prey density and foraging behavior, while simultaneously identifying the mechanisms (i.e. redundancy, complementarity) by which predator diversity determines the strength of this effect is critical to advancing our understanding of the roles of diversity and predation for ecosystem resilience. Dissecting these complex species interactions with unprecedented controlled field experiments to assess their causal relationships at scales relevant to real patch dynamics, combined with field surveys to evaluate their manifestation at scales of the whole ecosystem (kelp forests) collectively constitute the transformative potential of this research. Kelp forest ecosystems throughout temperate oceans in both southern (South America, New Zealand, Tasmania, southern Australia) and northern (New England) hemispheres, especially along the West Coast of North America (Mexico to Alaska), have had profound influence on our understanding of how abiotic (e.g., storm disturbance) and biotic (especially the role of predators) processes determine ecosystem stability and resiliency. By exploring these species interactions in kelp forest ecosystems, we capitalize on an extraordinary foundation of ecological understanding, hence the rationale for our focus on this system. In addition, the results of this study will inform our understanding of the ecological consequences and reasons for the extent and duration of ecosystem-wide impacts of the current sea star wasting event.

Broader Impacts

The broader impacts of this study include: graduate and undergraduate training, public outreach, and informing conservation managers and policy makers. Graduate training will be achieved through co-mentoring of one graduate student funded by this award by the two PIs. The graduate student will be involved in field studies, develop a species interaction model to explore the hypothesized interactions, and participate directly in outreach efforts. Marine Biology is one of the largest majors at UC Santa Cruz, with 260 current undergraduates. The program serves a substantial proportion of underrepresented students, including many Latino students who are the first in their family to pursue a college education. Undergraduate students pulled from this rich pool, will assist graduate students, faculty and researchers in all aspects of the study.

Our outreach efforts will have three main audiences: K-12 students, the general public, and marine resource managers. These efforts will be designed to provide information about the ecosystem consequences of sea star declines and the role of predator diversity in contributing to the resiliency of kelp forest ecosystems. Our outreach efforts will target four unique opportunities: the Monterey Bay Aquarium, the Seymour Discover Center on the UCSC Coastal Science Campus, UCSC's Broader Impacts Office, and a popular interactive website on sea star wasting information.

Based on the close involvement in this project of sea otter observers trained by the Monterey Bay Aquarium (MBAq), the Aquarium's Conservation program will facilitate disseminating information about the study and its results through their extensive outreach program, including a huge K-12 educational program (see letter of commitment and support submitted by MBAq.

UCSC is strongly committed to Broader Impacts (BI) and has developed a BI Office to facilitate researchers achieving the broader impacts of their research (http://officeofresearch.ucsc.edu /broader-impacts/). Among the many outreach avenues identified by the BI Office, the Seymour Marine Discovery Center (http://seymourcenter.ucsc.edu/) located on UCSC's Coastal Science Campus provides a conduit to K-12 programs and general public who visit the Center. We will co-develop a video presentation with the Center's display team through this grant and a collaboration with the Science Communication program at UC Santa Cruz (http://scicom.ucsc.edu). This video will build upon existing work at the Seymour Center to develop a video display, funded by earlier NSF support (see letter of commitment and support from the Center's Director).

Associated investigator Raimondi maintains a website and interactive map for tracking the incidence of sea star wasting (http://www.eeb.ucsc.edu/pacificrockyintertidal/dataproducts/ sea-star-wasting/), which we will continue to inform throughout the project. This website provides information to the interested public as well as a nexus for information exchange between scientific colleagues.

Management and policy institutions whose decisions and actions will benefit from the findings of this project include California's Department of Fish and Wildlife (CDFW) and Ocean Science Trust, which houses the state's Monitoring Enterprise. Both agencies are tasked with monitoring and managing marine protected areas (MPAs). Both institutions will benefit from knowledge of the ecological mechanisms that may underpin the geographic variation, including inside and outside of MPAs, in the dynamics of the wasting event, including the ecosystem-wide consequences of reduced sea star densities, and the mechanisms of resiliency of kelp forests. The PIs are well situated to ensure that this study informs MPA managers in California. PI Carr and associated investigator Raimondi both work closely with California's Monitoring Enterprise (http://monitoringenterprise.org/where/california.php) and the CDFW on the monitoring, assessment and applications of MPAs (see Synergistic Activities sections of their CVs). Federal agencies that will benefit from knowledge generated by the study include The Monterey Bay National Marine Sanctuary (MBNMS), tasked with evaluating and protecting the status of the Sanctuary's ecosystems, and the USGS Western Ecological Research Center, responsible for understanding both the ecological significance of the otter and processes that influence its recovery (e.g., kelp forest resiliency). Involvement of associated investigator Lonhart (MBNMS) and Co-PI Tinker (USGS) will ensure that MBNMS and USGS are well informed of the results of this study.

Results from prior NSF support:
(a) NSF award number: OCE-1041454, **amount:** $465,078, **period of support:** 07/15/2010 - 06/30/2014, Mark H Carr, Principal Investigator, James A Estes, Co-Principal Investigator. Dr. Jennifer Caselle was Principal Investigator on the **collaborative award number:** OCE-10411489.
(b) title: CAMEO: Comparative Approaches to Predicting the Consequences of an Impending Re-Invasion: Top Predator Effects on Californian Near-Shore Fisheries

DEPARTMENT OF THE NAVY
THE ASSISTANT SECRETARY OF THE NAVY
(ENERGY, INSTALLATIONS AND ENVIRONMENT)
1000 NAVY PENTAGON
WASHINGTON DC 20350-1000

December 12, 2016

MEMORANDUM FOR CHIEF OF NAVAL OPERATIONS

SUBJECT: Southern Sea Otter Military Readiness Area Monitoring Plan

Reference: (a) National Defense Authorization Act for Fiscal Year 2016
(b) Endangered Species Act of 1973 (16 U.S.C. 1531 et seq.)
(c) Marine Mammal Protection Act of 1972 (16 U.S.C. 1361 et seq.)
(d) ASN (EI&E) memo to CNO of 13 Apr 2016
(e) USFWS ltr 08EVEN00-2017-B-0020 of 23 Nov 2017

Enclosure: (1) Monitoring and Research Plan for Southern Sea Otter Military Readiness Areas

The proposed Monitoring and Research Plan for Southern Sea Otter Military Readiness Areas, outlined in enclosure (1) is approved.

Background. Section 312 of reference (a), directed the Secretary of the Navy to establish Southern Sea Otter Military Readiness Areas (Sea Otter Areas). Within these designated Sea Otter Military Readiness Areas, Sections 4 and 9 of reference (b) and Sections 101 and 102 of reference (c) shall not apply to incidental takings of any southern sea otters in the course of conducting a military readiness activity.

Reference (d), assigned management, operation and reporting for Southern Sea Otter Military Readiness Areas to the United States Navy and fulfills the requirement to develop monitoring and research parameters and methods in consultation with the United States Fish and Wildlife Service (USFWS).

If you have any questions, my point of contact for this matter is Mr. John Pierson at 703-693-1785, john.c.pierson@navy.mil.

Dennis V. McGinn

cc:
Assistant Secretaries of the Navy
General Counsel of the Navy
DON Assistant for Administration

Monitoring and Research Plan for Southern Sea Otter Military Readiness Areas

U.S. Navy and U.S. Fish and Wildlife Service
in coordination with
U.S. Geological Survey

I. INTRODUCTION

The National Defense Authorization Act for Fiscal Year 2016 (NDAA) includes provisions directing the Secretary of the Navy to establish Southern Sea Otter Military Readiness Areas (Areas) at San Nicolas Island and San Clemente Island (Figure 1). Military readiness activities[1] conducted within these Areas are subject to certain exemptions under the Endangered Species Act of 1973, as amended (ESA) and Marine Mammal Protection Act of 1972 (MMPA). Specifically, with respect to the ESA, Sections 4 and 9 do not apply to the incidental taking of any southern sea otter in the Areas in the course of conducting a military readiness activity, and any sea otter within the Areas is to be treated for the purposes of section 7 as a member of a species that is proposed to be listed as endangered or threatened under the ESA. With respect to the MMPA, Sections 101 and 102 do not apply with respect to the incidental taking of any sea otter in the Areas in the course of conducting a military readiness activity.

The NDAA also specifies monitoring requirements for these Areas:

(1) IN GENERAL.—The Secretary of the Navy shall conduct monitoring and research within the Southern Sea Otter Military Readiness Areas to determine the effects of military readiness activities on the growth or decline of the southern sea otter population and on the nearshore ecosystem. Monitoring and research parameters and methods shall be determined in consultation with the U.S. Fish and Wildlife Service (USFWS).
(2) REPORTS.—Not later than 24 months after the date of the enactment of this section and every three years thereafter, the Secretary of the Navy shall report to Congress and the public on monitoring undertaken pursuant to paragraph (1).

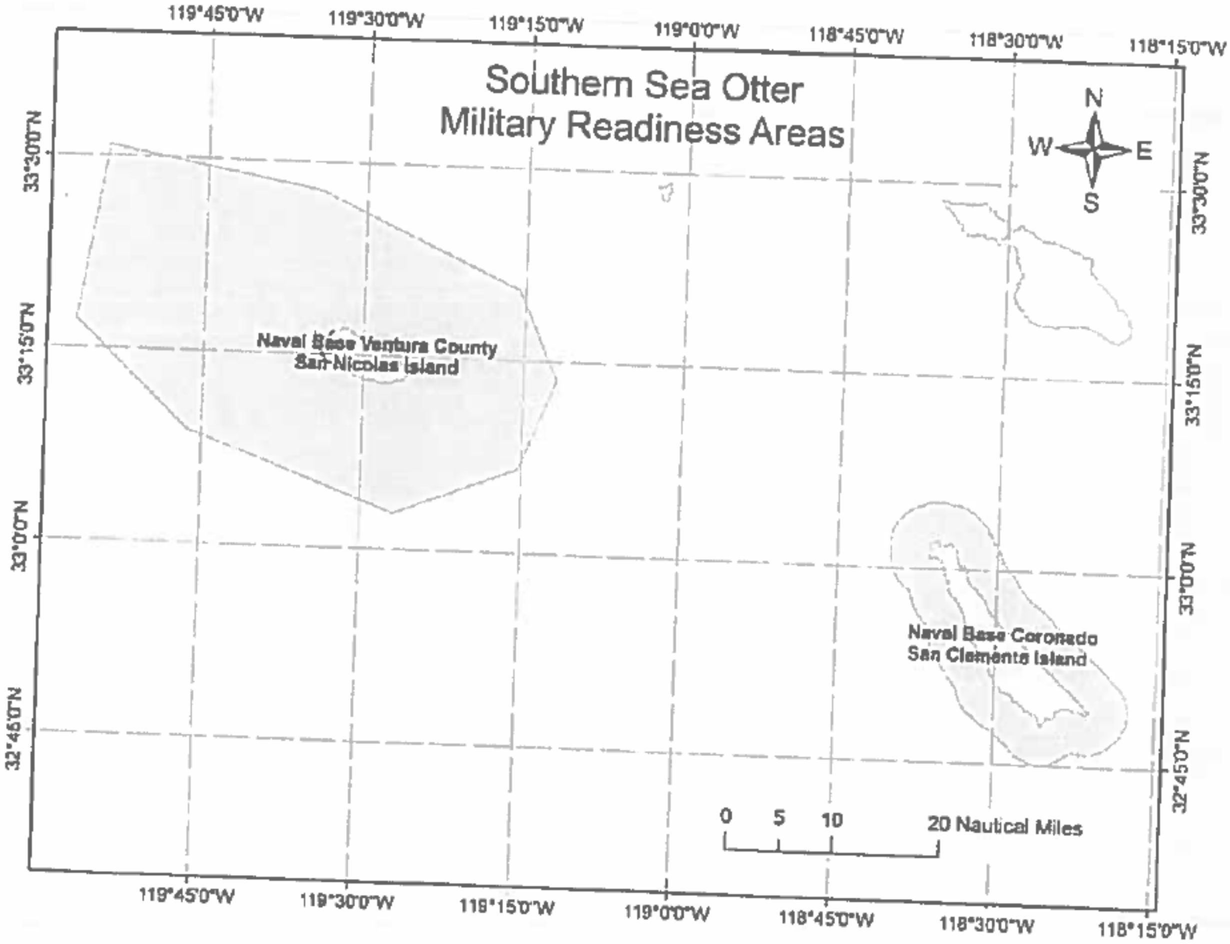
This document contains the research and monitoring plan for the San Nicolas Island Military Readiness Area (SNI Area). Required research and monitoring in this plan are tiered, using population status (increasing, stable, or decreasing) and changes in military readiness activities as triggers for the level of research and monitoring proposed.

Because sea otters do not yet occur at San Clemente Island and may not occur there for decades, preparation of a monitoring plan for the San Clemente Island Military Readiness Area (SCI Area) will not occur until at least three sea otters are present for at least twelve consecutive months or at least one female with a pup is detected. Marine and nearshore natural resource studies and monitoring activities currently occur in the areas around SCI to monitor for other species and habitats of concern. These studies and monitoring events will suffice to detect the presence and persistence of sea otters should they occur in the SCI Area in order to inform at what point a monitoring program under the law will be triggered. This document will be

[1] According to the NDAA, "The term 'military readiness activity' has the meaning given that term in section 315(f) of the Bob Stump National Defense Authorization Act for Fiscal Year 2003 (16 U.S.C. 703 note) and includes all training and operations of the armed forces that relate to combat and the adequate and realistic testing of military equipment, vehicles, weapons, and sensors for proper operation and suitability for combat use."

reviewed by Navy and USFWS every three years after completion of reports to ensure the plan continues to adequately monitor interactions between military readiness activities and the sea otter population.

Figure 1. Southern Sea Otter Military Readiness Areas.



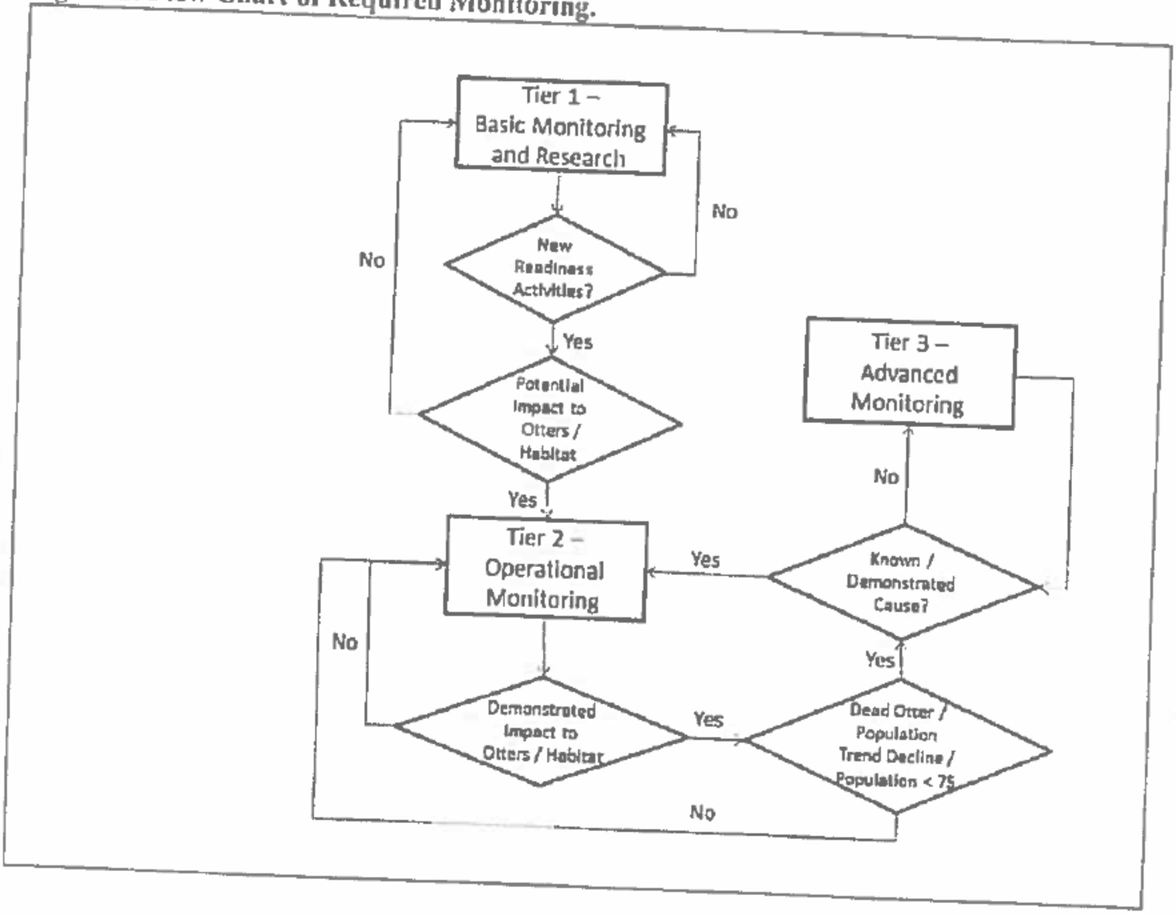
II. MONITORING AND RESEARCH PLAN FOR THE SNI AREA

The monitoring plan outlined below and in Figure 2 contains three tiers. The first tier is Basic Monitoring, which represents monitoring and research required given the current status of the sea otter population and currently occurring military readiness activities. Tier 1 efforts will continue as long as military readiness activities remain constant. The second tier is Operational Impact Monitoring. This higher level of monitoring would be required for any new military readiness activity[2] with a potential to impact sea otters or sea otter habitat. The third tier is Advanced

[2] For the purposes of this plan, a new activity is any activity that would require preparation of an Environmental Assessment or Environmental Impact Statement under NEPA with an area of potential effect within sea otter habitat. Existing activities are described in current NEPA documentation (Appendix 1).

Monitoring, which is triggered if new military readiness activities, as described in Tier 2, are occurring and any of the following conditions is also met: (1) a single dead, moribund, or stranded sea otter with injuries consistent with impacts from the activity (as determined by an independent pathologist) is detected; (2) the sea otter population trend at SNI decreases by more than 10% from the average SNI sea otter population trend over the preceding three-year period[3] for at least two consecutive years for reasons that cannot be reasonably attributed to anticipated density-dependent reductions in growth (see Tier 1, objective 3); or (3) the total sea otter population at SNI drops below 75. If additional funding or outside partnerships allow, Tier 2 and Tier 3 monitoring may occur even if military readiness activities and sea otter population trends remain stable.

Figure 2. Flow Chart of Required Monitoring.



[3] A 10% decrease in population trend would be determined after correcting for observer or measurement error, using State-Space model analysis of the survey time series or comparable method. Using the current average annual population increase of 1.1, for example, a 10% decrease would lead to no increase in population between years (rate of 1.0).

a. **Tier 1 Basic Monitoring and Research**

1. Objectives for Tier 1 monitoring

The overarching monitoring goal articulated in the NDAA (to determine the effects of military readiness activities on the growth or decline of the southern sea otter population and on the nearshore ecosystem) can be split into four specific objectives that, taken together, will ensure that this broader goal is achieved. These Objectives are:

1. *Monitor and analyze population trends at San Nicolas Island.* Data on trends in sea otter abundance are necessary to assess effects of various stressors on the population. In addition to conducting regular surveys, data will be analyzed using dynamical demographic models to infer baseline population parameters (i.e., annual growth rates and environmental variability). Such data are necessary but not sufficient on their own to determine *causes* of population trends.
2. *Monitor and analyze subtidal benthic communities and assess impacts of sea otter recovery on food web dynamics.* Another core dataset necessary for evaluating impacts on nearshore ecosystem health (with respect to sea otter populations) is monitoring data on benthic subtidal communities, including trends in abundance of foundational species such as kelp and key invertebrates such as urchins and abalone. These data should be analyzed using dynamical multi-species food web models in order to interpret the interacting effects of bottom-up forces (e.g., temperature, wave events) and top-down forces (e.g., increasing predation from sea otters).
3. *Determine the factors affecting population change. Specifically, assess the relative contributions of density-dependent factors (changes in per-capita prey abundance) and density-independent factors (e.g., shark mortality, military readiness activities) to variation in growth rates.* Extensive research on sea otter populations in California has demonstrated that the most common factor leading to localized reductions in population growth is density-dependent resource limitation. The rate of growth of a local population is generally high at low population densities (as has been the case at San Nicolas over the past 20 years) but will slow as populations approach local carrying capacity. The ultimate factor limiting growth is per-capita prey abundance, although resource-limitation may be manifested as increased mortality due to disease and emaciation. Therefore, in order to assess whether some other putative threat is influencing population trends at a given location (e.g., shark bite mortality, entanglement in fishing gear, contaminant exposure, etc.), it is necessary first to account for the role of density-dependent factors. Sea otters are almost unique among marine mammals, in that it is possible to accurately infer population status from a number of easily measured indices, including behavioral parameters (foraging success, percent time feeding), individual body condition, and direct measurements of the abundance and size distribution of key prey species, such as sea urchins. By tracking these indices over time, it has been possible in central California to determine the causal role of density-dependent resource limitation in slowing population growth, and this determination should be even more feasible at San Nicolas due to the existence of better baseline data sets. Achieving this objective will be critical for making a meaningful assessment of the effects of other factors on population growth, including military readiness activities.

4. *Describe habitat use by sea otters at San Nicolas and identify habitats necessary for vulnerable life history stages and behaviors.* Sea otters typically exhibit highly localized patterns of habitat use, which can vary by activity type and by demographic group. For example, resting activity generally occurs in dense kelp canopies, though not all kelp beds are used equally, and certain kelp beds are highly preferred by certain demographic groups (sub-adult males, or females with pups). In contrast, foraging activity more typically occurs along the outer margins of kelp beds and off of emergent rocks. Furthermore, the limited home ranges of most sea otters means that habitat utilization can vary at the scale of kilometers. Understanding home range and habitat use patterns is therefore critical for determining which specific areas around San Nicolas may be most sensitive in terms of the potential for military readiness activities to affect sea otter behavior or health. For example, an area used as resting habitat by reproductive females will be far more sensitive (in terms of the potential to affect population growth) than areas used for feeding by males.

2. Proposed Study Plan for Tier 1 Monitoring

To achieve the above four objectives, a multi-faceted approach consisting of the following tasks is proposed:

Task 1, Objectives 1 and 4. Population Surveys (All Years). An effective survey program for monitoring trends in sea otter abundance at San Nicolas Island is already in place: since the late 1980s, the USGS has annually conducted between two and four island-wide exhaustive sea otter counts, which are compiled in a GIS-compliant data set on abundance and distribution (see Tinker and Hatfield 2015). Surveys are currently conducted twice per year (spring and fall) to provide key data on trends in total abundance and also distribution of sea otters around the island. The frequency of these island-wide surveys would be increased to four times per year for the next four years to provide a higher resolution data set on seasonal variation in distribution and habitat use. These surveys would also provide initial data on important habitat areas around SNI. After four years, power analysis of the existing data can be performed to determine whether reduced effort at two surveys per year will be sufficient for accurate estimation of trends and achievement of other objectives (see Tasks 2 through 4).

Task 2, Objectives 2 and 3. Ecosystem Monitoring (All Years). As with Task 1, subtidal monitoring and kelp canopy monitoring programs are already in place, with twice-annual subtidal surveys conducted by USGS for the past 35+ years (Kenner et al., 2013) and annual kelp canopy surveys conducted by the Navy. For USGS subtidal monitoring, data on the relative abundance of benthic invertebrates, kelps, and fish are collected from seven permanent subtidal sites using standardized SCUBA methods. The resulting data set represents one of the most comprehensive and long-term time series on subtidal ecosystem dynamics worldwide. It can be used to infer the effects of physical disturbance (e.g., large wave events or El Niño conditions) and food-web perturbations (e.g., the recovery of sea otters, disease outbreaks) on community structure and dynamics. For Navy kelp canopy monitoring, multi-spectral kelp canopy images are collected annually via aircraft overflight, processed to determine both surface and subsurface kelp canopy to a 30 cm resolution, and input into a GIS dataset. Subtidal monitoring surveys and kelp canopy overflights would continue at the current frequency.

Task 3, Objectives 3 and 4. Collection of Foraging Data from Untagged Sea Otters (Years 1-2). A number of key indices for determining the population status of sea otters can be assessed from observational data on sea otter feeding. As food resources become more limiting, sea otter diets become more diverse at the population level and more specialized at the individual level, and the average rate of energy gain decreases (Tinker et al., 2008(b), 2012). Two of these indices (diet diversity and rate of energy gain) can be measured using standardized methods for collecting feeding data from untagged sea otters following previously established protocols (Tinker et al., 2008(b)). Earlier studies of sea otter diet and foraging behavior (1987-93, 2004-07), can be compared with current data to determine how sea otter prey choice and foraging success have changed over the last decade. These data will provide one important step towards achieving *Objective 3* and will also allow us to collect baseline data on sea otter distribution, behavior, and habitat use (*Objective 4*). They will also be invaluable for planning future capture and tagging operations, if needed (refer to Tier 3). Foraging data collection will occur concurrently with regular surveys for distribution and abundance (*Task 1*).

Task 4. Data Integration, Analysis, and Reporting (All Years). All field data collected will be entered in a geo-referenced Access database. Population dynamics will be analyzed using published methods to model sea otter populations (Clark and Bjornstad, 2004; Tinker, 2015; Tinker et al., 2006). Data on sea otter locations and habitat use will be analyzed in GIS using spatial tools and compared with ecosystem and habitat data. Statistical analysis may include logistical regression (habitat use vs availability), Maximum Entropy Models and General Additive Model (GAM). A series of high resolution GIS digital maps will be created to summarize all spatial data and analysis results and to facilitate identification of important habitats for sea otters (habitats most frequently used for feeding and resting).

To evaluate ecosystem-effects of sea otter populations at San Nicolas Island (*Objective 2*), an existing Ecopath mass-balance food web model for sea otters and kelp forests will be modified by combining the dietary data collected during this project and the concurrent subtidal monitoring data (see Kenner et al., 2013), and projections of food web dynamics in response to sea otter predation will be conducted using Ecopath/Ecosim. Community interaction matrix approaches will be used to analyze and forecast food web dynamics. Both approaches will allow us to estimate the range and magnitude of ecosystem services associated with the recovery of sea otters.

b. <u>Tier 2 Operational Monitoring</u>

1. Objective for Tier 2 Monitoring

Operational monitoring under Tier 2 would be required for any new military readiness activity with a potential to impact sea otters or sea otter habitat. At present there are no proposed new military readiness activities with potential to impact sea otters or sea otter habitat and there are no data suggesting continuing activities demonstrate significant disturbance effects. Furthermore, the existence of a measurable disturbance effect would not by itself imply an impact on population growth (indeed, the relatively rapid rate of population growth at San Nicolas Island compared to the mainland population over the past 20 years would suggest that there have been minimal or no effects of disturbance on sea otter populations to date). Rather, the benefit of examining this question would be to provide useful data on the types of disturbance that elicit a response and the contexts in which effects on behavior or energy expenditure are most likely to

occur. Such information could be useful for planning purposes in future military readiness activities and for identifying potential problems before they occur.

1. *Assess the effects of disturbance on behavior and energetics.* In order to determine whether new military readiness activities have the potential to affect sea otter populations, it will be helpful to elucidate the likely mechanisms by which such an effect would occur. Specifically, certain types of activities may elicit a behavioral response (disturbance) and possibly impact individual energy expenditure (depending on the magnitude of response to the disturbance).

2. Proposed Study Plan for Tier 2 Monitoring

To achieve this objective, the following task is proposed for new military readiness activities at SNI with a potential to impact sea otters or sea otter habitat:

Task 1. Real-time Monitoring of Sea Otter Reactions. For any new military readiness activity with a potential to impact sea otter behavior, real-time monitoring of sea otter responses to the activity will occur. To detect behavioral responses and distinguish these from background levels of activity, a "Before-After-Control-Impact" (BACI) design will be used. The BACI experimental design requires sampling to be conducted at both control sites and "impact" (treatment) sites at repeated intervals before and during/after the activities in question. Behavioral sampling will be conducted using one of three methods: (1) If possible, sea otters will be monitored by Navy biologists using high-power telescopes from shore, after receiving training from USGS biologists in standardized scan-sampling methods for measuring the behavior of sea otters. Training will cover basic scan sampling protocols and the categorization of behaviors using standard sea otter ethograms. Note that direct monitoring can occur only if sea otters are present in areas visible by telescope and outside hazard patterns that preclude human presence; (2) Unmanned aerial vehicles (UAVs) may be used to observe sea otters either farther from shore or during events when hazard patterns preclude human presence. UAVs will be equipped with high-resolution video cameras that allow the observation of behavioral changes. In the case of this option, Navy personnel will work with USGS biologists to validate UAV data collection techniques via comparisons with data collected by human observers; (3) If in place, archival data logging tags described under Tier 3 monitoring would replace the previous two methods (see below).

c. Tier 3 Advanced Monitoring

1. Objective for Tier 3 Monitoring

Advanced monitoring would be required in the event that new military readiness activities as described in Tier 2 are occurring and any of the following conditions is also met: (1) a single dead, moribund, or stranded otter with injuries consistent with impacts from the activity (as determined by an independent pathologist) is detected; (2) the sea otter population trend at SNI decreases by more than 10% from the average trend over the preceding three-year period for at least two consecutive years for reasons that cannot be reasonably attributed to anticipated density-dependent reductions in growth (see Tier 1, objective 3); or (3) the total sea otter population at SNI drops below 75. This monitoring would focus on providing a more detailed analysis of habitat use, emigration (if occurring), and reactions to specific activities. If no substantial effect from military readiness activities on sea otter health is detected and a reason for

the declining growth trend is known (e.g., shark bite mortality or food limitation, as substantiated by other monitoring). Tier 3 monitoring would not be required.

After a second consecutive year of change by more than 10% from the current sea otter population trend following the occurrence of new military readiness activities, the Navy will secure funds as quickly as possible to initiate any advanced monitoring requirements. Advanced monitoring will begin when these new funds become available. Advanced monitoring may also benefit earlier objectives, as described, and will be supported prior to the Tier 3 trigger if additional funding or partnerships become available.

2. Proposed Study Plan for Tier 3 Monitoring

To achieve this objective, the following tasks are proposed:

Task 1. Capture, Tagging, and Sampling. In compliance with all applicable Federal laws and statues, a sample of approximately 25 sea otters at San Nicolas Island will be captured and tagged, following methods utilized for many similar studies in the past, including one conducted previously at San Nicolas Island (Tinker et al., 2008(a)). Captures are conducted by a highly experienced and uniquely trained sea otter capture team using specialized closed-circuit SCUBA methods (Ames et al., 1983). Divers swim out from small skiffs, guided by radio transmissions form the skiff operator and shore-spotters, and position underneath a potential resting sea otter. The divers then swim upwards and entrap the resting animal in a Wilson trap attached to an underwater propulsion device. The captured animals are then transported back to a support vessel for processing by a veterinary team.

All captured animals will be anaesthetized and tagged and will receive comprehensive health exams and bio-sampling. Each animal is equipped with colored flipper tags for visual identification, a surgically implanted VHF transmitter for radio tracking, and a time-depth recorder (TDR) for bio-logging of diving activity. VHF frequencies will be deconflicted with Navy working frequencies to avoid any mission impact. Analysis of morphometric data and health parameters, and comparison of these with other sub-populations in California and with previously captured animals at San Nicolas Island (2005-07), will also contribute towards accomplishing Tier 1, *Objective 3.*

Task 2. Telemetry-based Monitoring of Tagged Animals (2Years). After release, study animals will be monitored regularly (using standardized VHF telemetry protocols) by shore-based observers. This phase will continue for two years past tagging (pending support for follow-on work). Field personnel will conduct shore-based daily surveys of the study site using standard telemetric protocols (triangulation on radio signal using VHF telemetry receivers and visual identification using 50-80X Questar spotting scopes: see Tinker et al., 2006, 2008) to locate all study animals within the study area and record precise GPS position, survival, reproductive status, and instantaneous behavior. Attempts will be made to re-sight all study animals at least five times per week. A series of intensive focal-animal observation sessions will be established to collect detailed behavioral data. During these 12-hour focal animal monitoring sessions, data will be recorded at 10-minute intervals on the individual's activity state, diet, dive behavior, distance-to-shore and fine-scale movements (habitat use). Whenever study animals feed during these activity sessions, continuous data will be recorded on dive/surface intervals and prey capture rates and handling times following previously established protocols (Tinker et al., 2008(b)). The anticipated schedule of focal-animal observation sessions is two sessions per

week, with a goal of obtaining three sessions for each study animal. These data, and comparisons with similar data from other populations, provide additional information for characterizing habitat use patterns (Tier 1, *Objective 4*), foraging success and status with respect to prey resources (Tier 1, *Objective 3*), and predator-prey interactions and ecosystem impacts (Tier 1, *Objective 2*).

Task 3. TDR Retrieval and Analysis. After two years of deployment, a second capture operation will recapture previously tagged otters. Recaptured animals will undergo another surgery in order to retrieve the implanted TDR (containing two years of bio-logged diving and temperature data), and a second set of morphometric and bio-health samples will be collected. *Note that at this time a subcutaneous networking tag programmed for short-distance communications and data sharing between otters (and between otters and a buoy equipped with a data retrieval unit) would be implanted.* Data from the retrieved TDR units will be downloaded and analyzed, following established methods, in order to obtain detailed information on time-activity budgets, foraging behavior and diving depth, and reproductive parameters, thereby contributing to Tier 1, *Objectives 3 and 4*. Because the data on behavior have a high resolution (2-second interval between depth readings), it will be possible to relate changes in activity to specific events that occurred over the two-year period, thereby contributing to the Tier 2 objective of identifying reactions to specific events. Existing Navy data on operational dates and times will be used to cross-reference with TDR data.

III. TENTATIVE BUDGETS[4]

Note: The Navy will provide funding for all costs described below. The following budget is divided into expenses associated with implementing Tier 1, 2 and 3. Existing funding for activities already underway is included within Tier 1 expenses (grey highlight).

Tier 1 Budget

Tier 1 Budget Category	Budget Line Item	FY16 Budget Amount	FY17[1] Budget Amount	FY18 Budget Amount	FY19 Budget Amount
USFWS					
Salary	SSO Recovery Coordinator--up to 4 5-day trips/year for data collection w/USGS personnel ($68/hour x 8 hr x 5 days)[1]	$2,732	$10,928	$10,928	$10,928
Travel	Field travel to-from field site plus per diem expenses ($1000/trip)[1]	$1,000	$4,000	$4,000	$4,000
	USFW Sub-total	$3,732	$14,928	$14,928	$14,928
	Indirect Costs @ 22%	$821	$3,284	$3,284	$3,284
	USFWS Total	$4,553	$18,212	$18,212	$18,212
USGS					
Salary	Principal Investigator – to oversee project, study design, conduct analyses, finalize reports ($109/hour for 80 hours each year)	$8,720	$8,720	$8,720	$8,720
Salary	Researcher/Project Biologist – to oversee field research and documentation, assist with analysis, and develop reports ($55/hour for 120 hours year 1 and 360 hours years 2 to 4)	$6,600	$19,800	$19,800	$19,800
Salary	Two Research Assistants to support and assist the Project Biologist ($27/hour for 60 hours year 1, 320 hours years 2 to 4)	$1,620	$8,640	$8,640	$8,640
Salary	Additional support for research biologist or graduate sudent to asssist with Food web model development	n/a	n/a	$12,000	$12,000
Materials/ Supplies	Miscellaneous Supplies for sea otter montiroing	$2,000	$1,000	$1,000	$1,000
Travel	Field travel for personnel to-from field site plus per-diem expenses, 3 personnel for 4 data collection field trips of 5 days each	$2,000	$8,000	$8,000	$8,000
Subtidal	Support for Charters, UCSC salary and miscellaneous supplies associated with Subtidal Monitoring, $60K per year[2]	$39,475	$39,475	$39,475	$39,475
	USGS Sub-total	$60,415	$85,635	$97,635	$97,635
	Indirect Costs @ 52%	$31,416	$44,530	$50,770	$50,770
	USGS Total	$91,831	$130,165	$148,405	$148,405
USN					
Kelp Canopy	Support for aerial kelp canopy imagery collection and GIS layer compilation[3]	$9,497	$9,677	$9,874	$10,088
	USN Total	$9,497	$9,677	$9,874	$10,088
	Tier 1 Total	$105,881	$158,055	$176,492	$176,705

[1] Typical involvement is expected to be 1-2 trips/year. FY 16 lower in several areas due to partial year funding. Excess funds will be returned to the Navy.
[2] Current funding of $60 K per year provided by NAVFAC to USGS.
[3] Current funding of $10 K per year provided by NAVAIR contract.

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[4] No provision of this plan shall be interpreted as constituting a commitment or requirement that the United States is obligated to pay funds in contravention of the Anti-Deficiency Act, 31 U.S.C. § 1341, or any other provision of law.

Tier 2 Budget

Tier 2 Budget Category	Budget Line Item	FY 1 Budget Amount	FY 2 Budget Amount	FY 3 Budget Amount	FY 4 Budget Amount
Salary	Principal Investigator – to oversee project, study design, conduct analyses, finalize reports ($109/hour for 40 hours each year)	n/a	$4,360	$4,360	$4,360
Salary	Researcher/Project Biologist – to oversee field research and documentation, train and collaborate with Navy biologists, ($55/hour for 80 hours years 2 to 4)	n/a	$4,400	$4,400	$4,400
	Sub-total		$8,760	$8,760	$8,760
	Indirect Costs @ 52%		$4,555	$4,555	$4,555
	Tier 2 Total		$13,315	$13,315	$13,315

Tier 3 Budget

Tier 3 Budget Category	Budget Line Item	FY 1 Budget Amount	FY 2 Budget Amount	FY 3 Budget Amount	FY 4 Budget Amount
Salary	Principal Investigator – to oversee project, study design, conduct analyses, finalize reports ($109/hour for 40 hours years 2 to 4)	n/a	$4,360	$4,360	$4,360
Salary	Researcher/Project Biologist – to oversee field research and documentation, assist PI with analysis, develop reports ($55/hour for 1200 hours years 2 to 4)	n/a	$66,000	$66,000	$66,000
Salary	Research Assistant to support and assist the Project Biologist ($27/hour for 1200 hours years 2 to 4)	n/a	$32,400	$32,400	$32,400
Vessel Charter	Support Vessel for Capture operations	n/a	$35,000	n/a	$35,000
Travel	Field travel for personnel to-from captures, plus per-diem expenses	n/a	$10,000	n/a	$10,000
Travel	Field travel for personnel to-from field site plus per-diem expenses	n/a	$25,160	$25,160	$25,160
Equipment	2 VHF tracking receiver	n/a	$2,000	n/a	n/a
Equipment	2 Field Handheld computers for Data Collection	n/a	$2,000	n/a	n/a
Equipment	1 Laptop Computer, data entry	n/a	$2,000	n/a	n/a
Equipment	Buoy/receiver for recording otter network data	n/a	$2,000	n/a	n/a
Materials/ Supplies	Surgical and sampling supplies @ $800 each	n/a	$20,000	n/a	$20,000
Materials/ Supplies	VHF Telemetry tags @ $1000 each	n/a	$25,000	n/a	n/a
Materials/ Supplies	Time Depth Recorders, 15 @ $1200 each	n/a	$18,000	n/a	n/a
Materials/ Supplies	Miscellaneous Supplies	n/a	$5,000	$2,000	$2,000
	Sub-total		$248,920	$129,920	$194,920
	Indirect Costs @ 52%		$129,439	$67,558	$101,358
	Tier 3 Total		$378,359	$197,478	$296,278
	Grand Total - All Tiers	$105,881	$549,729	$387,285	$486,298

IV. LITERATURE CITED

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Appendix 1
List of Current Navy NEPA documents
San Nicolas Island

Document Title	Date	Brief Description
Environmental Assessment Directed Energy Test Facilities at San Nicolas Island	2015 Jun	Directed Energy test facility construction and operations
Environmental Assessment/Overseas Environmental Assessment Point Mugu Sea Range Expansion of Unmanned Systems Operations	2015 Feb	Increased use of both unmanned aerial vehicles and unmanned surface vehicles on the Sea Range
Environmental Assessment Point Mugu Sea Range Countermeasures	2014 Jul	Use of various countermeasures, including guns, directed energy, chaff, flares, and others on the Sea Range
Final Environmental Assessment for Obtaining California Sea Lions for Service in the Navy Marine Mammal Program	2012 Dec	Collection of live sea lions from San Nicolas Island
Final Environmental Assessment/Overseas Environmental Assessment Laser Testing and Training Naval Air Warfare Center Weapons Division Sea Range, Point Mugu, California	2010 Jun	Testing and training with lasers at Point Mugu and San Nicolas Island
Final Environmental Assessment SSM-1 KAI Missile Testing at San Nicolas Island	2007 Mar	Testing and training with Japanese Defense Forces missile system
Environmental Assessment FOCUS Cable Repair – San Nicolas Island, CA	2003 Sep	Repair of undersea fiber optic cable
Arrow System Improvement Program Environmental Assessment	2003 Nov	Testing and training with Israeli Defense Forces missile system
Final Environmental Impact Statement/Overseas Environmental Impact Statement Point Mugu Sea Range	2002 March	Programmatic coverage for Sea Range testing and training activities
Construction and Operation of a Supply Pier on San Nicolas Island	2002 Sep	Pier constructions at San Nicolas Island
Final Environmental Assessment/Overseas Environmental Assessment Harpoon BLOCK II Development Test 2 on the Point Mugu Sea Range	2001 Dec	Testing and training with Harpoon missile systems on Sea Range
Addendum to the EA for Tomahawk Flight Test Operations on the West Coast of the United States	2000 Nov	Addition of a soft-landing area on San Nicolas Island for Tomahawk missile system testing and training.
Final Environmental Assessment - Tomahawk Flight Test Operations on the	1998 Oct	Testing and training with Tomahawk missile systems on

Document Title	Date	Brief Description
West Coast of the United States		the Sea Range
Environmental Assessment Non-warhead Standoff Land Attack Missile (SLAM) Expanded Response (ER) Developmental Test & Evaluation Firings San Nicolas Island, Ventura County, California	1997 Oct	Construction and operation of an inert (non-warhead) target site on San Nicolas Island
Environmental Assessment of the Use of the Outer Sea Test Range for the Shock Trial of The DDG 53	1994 Apr	Shock trial for a specific Navy Destroyer
Environmental Assessment, Fiber Optic Communication Undersea System (Focus)	1989 Mar	Installation of an undersea fiber optic cable between Point Mugu and San Nicolas Island

Innovation Fund 2018 Proposal

INNOVATION CENTER

Next Generation Wildlife Tracking: A New Paradigm for Environmental Monitoring and Data Retrieval through Hybrid Heterogeneous Networks of Tagged Animals

The problem and the opportunity:

Advanced animal tracking devices that couple cutting-edge technologies with our increasing need for ecological data will be critical tools for managing and conserving species under future land use and climate conditions. In addition to optimizing the size of telemetry units for use on small or sensitive species, new paradigms for collecting, storing and transmitting data on animals and their environments are needed to further advance the next generation of wildlife tracking devices. We propose a follow-on effort to our previous Next Generation Wildlife Tracking development work. Phase 3 of our USGS-NASA collaborative project will mature the two tag architectures developed under Phase 1 (satellite communications tag) and Phase 2 (networked tags), and will explore new hybrid architectures enabled by using a mixture of the two tag types (e.g. heterogeneous networks).

Our successful Phase 1 and 2 efforts have resulted in several advances that address issues associated with modern day telemetry units. During Phase 1, we developed a novel tag to satisfy the challenging goals of providing a light-weight, energy-efficient, and low-cost device that could transmit geolocation and environmental sensor data via commercial satellite (Fig. 1). Additionally, research conducted in Phase 1 identified the need for a smaller, lighter, lower-cost tag that could collect and exchange data with other tags. Such information sharing among animals is a novel approach to maximizing data collection and delivery that has the added benefit of detecting patterns of association among individuals and subpopulations. In a peer-to-peer tracking network, animals can exchange stored location, activity, body condition, and environmental data when in close proximity, thereby improving energy-efficient data recovery (one individual can upload data from many; Fig. 2) and shifting the wildlife telemetry framework from geospatial tracking of a single animal, to one that can also acquire data about population connectivity.

In Phase 2, we developed peer-to-peer tracking capabilities (Fig. 3) and refined the early prototype satellite-communications tag created in Phase 1 to incorporate a unique antenna capable of both receiving GPS signals and transmitting to the Globalstar satellite constellation. Our Phase 2 work has advanced both devices, as well as a base station design for use with the networked tags, to the point of readiness for field testing. Research in Phase 2 also indicated the potential for "hybrid architectures" comprised of both multiple, interconnected networked tags, and one or more satellite tags. Such hybrid architectures offer the potential to leverage species associations with surrounding animal populations, and provide a mechanism for the data acquired by networked tags on small species to be collected by the satellite tags sited on larger species and ultimately relayed to scientists.

The overarching goal of our collaborative USGS-NASA Next Generation Wildlife Tracking project is to develop low-cost, modular hardware and custom software that will allow scientists to tailor tag technology for broad species applicability and large-scale deployments. To achieve this goal we have identified three parallel tasks for Phase 3 of our project (see timeline Fig. 4). In **Task 1**, field testing of the first generation of satellite tags, which was started in Phase 2, will be concluded and the results analyzed and incorporated into design revisions and improvements. The improved (Gen 2) satellite tags will be designed and prototypes fabricated. **Task 2** will advance the design of the networked tags. A set of base stations will be fabricated to enable field testing of the 1st-generation networked tags, and a set of tags for testing will be produced. These elements will be field-tested to assess function, radio range, and battery life. The results will be analyzed and used to evolve the tag design and prototype a Gen 2 peer-to-peer tag. For both the satellite and peer-to-peer

tags, software and hardware design and performance will be documented and published upon the completion to Gen 2 working prototypes.

Development of the hybrid architecture described above will form **Task 3.** Satellite and networked tags will be used to implement a hybrid system, which will then be tested to evaluate capabilities and suitability for the anticipated wildlife monitoring use. In particular, the achievable data throughput from the complete system will be assessed, for architecture variations of number of networked tags vs. number of satellite tags and/or base stations. The results of the **Task 3** activities will be documented in a published report. Our approach to all tasks will be open-hardware, open-software with the goal of producing low-cost reference designs that can be adopted, modified, and improved by commercial providers, universities, and other government labs. We will continue to engage with stakeholders from USGS and other agencies, including a developing NASA-BOEM project investigating employment of small satellites for telemetry data transmission.

Overall Goal or MVP (minimum viable product):

The Minimum Viable Product resulting from our collaboration will be a low-cost, miniaturized, wildlife GPS-satellite marking prototype with integrated environmental sensors optimized for size, battery life (or solar cell recharge), and peer-to-peer data transmission. To date, our team has advanced this goal by producing a miniaturized solar GPS-enabled Globalstar satellite transmitter with accelerometer capability (Fig. 2) that is 20% lighter and produced for 25% of the cost of existing commercial tags, as well as a novel peer-to-peer, solar-powered network tag and associated base station hardware. Our Phase 3 work will integrate components developed in Phases 1 and 2 to create a hybridized architecture of networked peer-to-peer and satellite tags.

Objectives and Activities:

Objectives	Activities
Reduce battery size and improve performance	Develop optimized battery using a combination of state-of- the-art technologies including commercially available batteries, NASA-Ames developed 3D-printed battery technology, and/or GaAs thin-film flexible photovoltaic cells for use in recharging batteries to extend life. **(ACHIEVED)**
Integrate environmental sensors	Incorporate between 1 and 3 exchangeable environmental sensors that are integrated into GSM or satellite data transmission systems. **(ACHIEVED – ACCELEROMETER INTEGRATED)**
Develop peer-to-peer networking capability	Build on existing hardware and communication protocols to allow wireless communication (handshake/data sharing) among tagged individuals when in close proximity, thus creating a peer-to-peer tracking network **(ACHIEVED)**.
Integrate system	Integrate Phase 1 and 2 to create a hybridized architecture that allows for networked communication among animals as well as data transmission via satellite
Test and modify designs	Throughout each task we will employ a spiral development approach in which prototype is developed and tested on one or more wildlife species, design is modified and the refined prototype is tested again.

How critical is Innovation Funding for the success of this venture?

Biotelemetry is critical for understanding both threats and conservation opportunities for the Nation's wildlife resources. Emerging technologies offer great promise for innovating wildlife tracking technology and significantly increasing the amount of information we can gain from traditionally hard-to-track species. While commercial telemetry companies have decreased device size and increased location accuracy, progress towards more effective tracking devices has been slow due to limited private-sector research and development. New information from cutting-edge telemetry devices has great applicability for USGS Ecosystems, Climate and Land Use Change, and Core Science Systems; however, development of the

necessary technology is somewhat outside the missions of these programs. Innovation funding, therefore, is an essential catalyst for bringing NASA's state-of-the-art technological research together with USGS ecological science. Our proposed project leverages USGS and NASA capabilities and takes advantage of rapidly-emerging innovations from the tech industry to develop a new device that will advance ecological knowledge. Our successful Phase 1 and 2 products demonstrate the effectiveness of the partnership between USGS and NASA and has resulted in significant advances towards developing our full MVP. Phase 3 development and testing would use additional Innovation Center funding to provide the necessary personnel and raw materials. Adapting consumer technology for wildlife tracking purposes will require manipulation of existing hardware and software to boost signal ranges and enable expanded use in the field. We will allocate requested funds toward new engineering and prototype testing to accomplish our objectives. Success from this project would dramatically improve our understanding of ecological community interactions, thus advancing our ability to conserve the Nation's resources.

Partner goals, contributions and expected technology transfer:

As federal science research agencies, both USGS and NASA have considerable interest in developing novel tools that can be used across the Nation to advance scientific understanding. Our USGS-NASA partnership takes advantage of NASA engineering and emerging technologies and to make advances in the size, utility and cost of wildlife tracking devices. We demonstrated the success of this partnership through our Phase 1 and 2 products, which include development of a working proof-of-concept satellite-GPS tag containing a novel antenna architecture, as well as prototype solar, peer-to-peer network tag. In workshops to demonstrate our Phase 1 and 2 prototypes, USGS researchers studying a wide range of species expressed enthusiasm for using these tools to study topics ranging from open ocean tracking to disease transmission. We propose to build upon previous success to conduct Phase 3, in which NASA will integrate Phase 1 and 2 tags into heterogeneous hybrid networks. This hybrid of close-range wireless transmission among animals and long-range satellite data transmission would be the first of its kind and would open the door to novel applications in wildlife tracking and conservation. We are working on new opportunities to partner with BOEM (J. Levenson) and NASA (A. Martinez) researchers developing a small satellite system for next generation data transmission. Our tags will be designed to integrate with this developing system to promote a complete next generation tracking system. We will continue to use an open hardware, open software approach to produce a broadly transferrable design that can be adopted, modified, and improved to foster additional innovations by private sector manufacturers, universities, and other government labs. The NASA-Ames Research Center (Frost, Kemp) will provide laboratory and "space shop" facilities, hardware and software engineering expertise. USGS will provide expertise on the ecology and marking of several avian and marine mammal taxa and will assist with overall design and testing of transmitter prototypes. This proposal supports multiple goals of the USGS Ecosystems Mission Strategy including: (iv) Developing tools and technologies to inform decision making about ecosystems, and (v) Applying science to enhance strategies for management, conservation, and restoration of ecosystems.

Personnel:

USGS PIs: Susan E. W. De La Cruz, San Francisco Bay Estuary Field Station, 505 Azuar Drive, Vallejo, CA 94592 sdelacruz@usgs.gov, (707) 562-2004; **Center name and location:** Western Ecological Research Center, Sacramento, California ; **Center Director:** A. Keith Miles, keith_miles@usgs.gov; **Center AO:** Tina Palmer, tpalmer@usgs.gov; **USGS collaborators:** Isa Woo, iwoo@usgs.gov; Mike Casazza, mike_casazza@usgs.gov; Cory Overton, coverton@usgs.gov; Josh Adams, josh_adams@usgs.gov; Joseph Tomoleoni, jtomoleoni@usgs.gov; Zachary Randell, randellz@oregonstate.edu **Technology Partners:** Chad R. Frost, Deputy Director, Engineering, NASA Ames Research Center, Moffett Field, CA 94035, chad@nasa.gov, (650) 604-1798; Dayne Kemp, Engineering and Integration, dayne.h.kemp@nasa.gov.

USSG Mission Area alignments:

Our proposal results would contribute towards the goals of the one or two following Mission Areas (check):
☒ Climate and Land Use Change ☒ Core Science Systems ☒ Ecosystems
☐ Energy and Minerals, and Environmental Health ☐ Natural Hazards ☐ Water
May we share your proposal with the Associate Directors for the Mission Areas you checked above?
☐ No ☒ Yes

Budget Summary

Category	Description	In-Kind Contributions	Request
Personnel: USGS WERC	2 PP support for USGS technician, field testing	5 PP WERC PIs wildlife and tracking expertise, field testing, meetings, documentation and outreach	$ 3,374
Personnel: NASA	6 PP Electrical Engineer; 3 PP Software Engineer; 3PP Mechanical Engineer	2 PP support for NASA PI engineering expertise	$ 93,626

Equipment and Supplies	Fabrication, COTs components	"Space shop" testing facilities	$ 10,000
Contracts	Antenna design		$ 20,000
Sub-total			$133, 626 (NASA) $ 3,374 (USGS)
Total	USGS Cost Center rate 25.795% ($870)	NASA funds through IA agreement, ($23,000)	$ 150,000

Commented [A1]: This needs to be adjusted based on actual NASA OH rate

FIGURES:

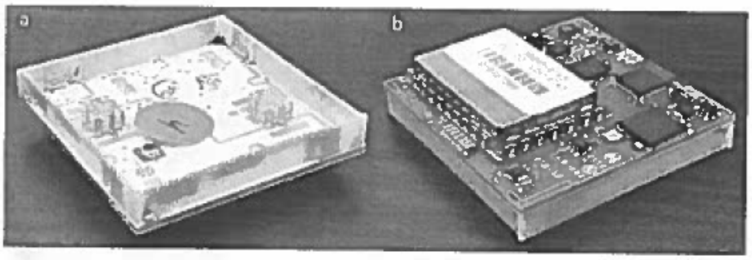

Figure 1. Prototype design for GPS-satellite tag showing (a) novel integrated antenna and (b) build-out of circuitry components. The build out is 20% lighter and 25% the cost of similar commercially available devices.

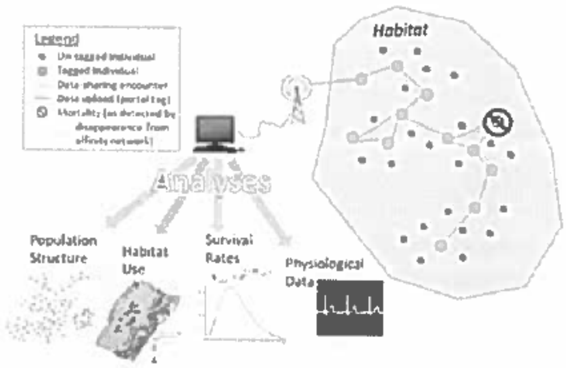

Figure 2. Conceptual model demonstrating capabilities of a peer-to-peer wildlife tracking network. Data are shared among individuals and uploaded from animals marked with portal tags. Analyses of location, sensor and interaction data advances our understanding of population structure, habitat use, survival, physiology and several other critical parameters.

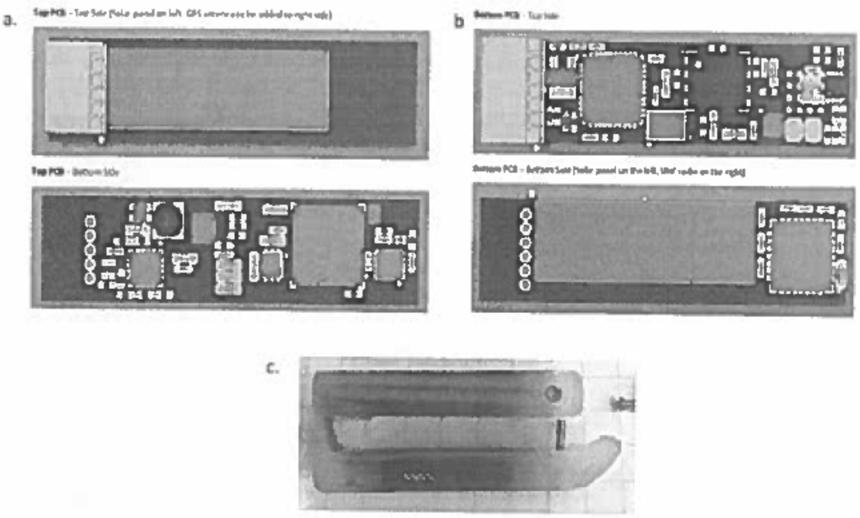

Figure 3. (a) Top and (b) bottom conceptual design of Phase 2 prototype solar, peer-to-peer network tag designed for a (c) flipper or ear tag form factor.

Figure 4. Phase 3 projected timeline.

UC Santa Cruz Institutional Animal Care and Use Committee (UCSC IACUC)
Phone: (831) 459-3150 | Fax: (831) 459-1452
Email: iacuc@ucsc.edu | Mail stop: Office of Research

Proposal Code: Tinkt1510_r2
Approval Date: October 5, 2017

Annual Protocol Update

Please fill out this form completely and send to iacuc@ucsc.edu. Enter N/A where not applicable. Questions and feedback regarding this form should be directed to iacuc@ucsc.edu.

In accordance with federal law, if an update is not approved by the anniversary date, December 15, 2017, all animal use activity under this protocol must stop and a new protocol application must be submitted and approved by the IACUC.

Submission date: 09/28/2017		
Project title: Population Dynamics and Biology of Sea Otters		
Principal investigator: Tim Tinker		
Department: Biology		
Phone: (831) 459-2357	Email: ttinker@ucsc.edu	Mail stop: LML
Co-respondent(s) on protocol communications: Michael Kenner mkenner@ucsc.edu		

1. Were animals used since your last annual update (or initial approval if protocol is in its first year)?

   Yes

2. If no animals were used, state reason (if animal use is complete and will not resume, you are finished):

   NA

3. If currently inactive, is animal use expected to resume? If so, approximate date? (if no, you are finished):

   NA

4. Specify by species animal numbers used since last approval or update:

   8 *Enhydra lutris* captured (2 of these underwent surgery for instrumentation)

5. Specify by species animals remaining (total approved less total used since initial approval):

   358 *Enhydra lutris,* 193 of which may be instrumented

6. If you have applied for funding through the UCSC Office of Sponsored Projects that you have not yet reported to UCSC IACUC, specify the funding agency and OSP Cayuse #. Failure to do so will delay distribution of any grant funds:

   NA

7. List all personnel approved to work on this protocol:

Name	Affiliation	Project Role	E-mail	Phone
Tim Tinker	UCSC	PI	tinker@biology.ucsc.edu	9-2357
Mike Kenner	UCSC	Co-Res	mkenner@ucsc.edu	254-5184
Dr. Mike Murray	SORAC/MBA	Senior Vet/SORAC	mmurray@mbayaq,org	
Marissa Young	SORAC/MBA	Vet Technician	myoung@mbayaq.org	
Brian Hatfield	USGS	Biologist	Brian_hatfield@usgs.gov	
Joe Tomoleoni	USGS	Biologist	jtomoleoni@usgs.gov	

IACUC

Ben Weitzman	USGS	Biologist	bweitzman@usgs.gov	
Jack Ames	CDFW/retired	Biologist	Jack.Ames@wildlife.ca.gov	
Mike Harris	CDFW	Biologist	Michael.D.Harris@wildlife.ca.gov	
Colleen Young	CDFW	Environmental Scientist	Colleen.young@wildlife.ca.gov	
Andrew Johnson	SORAC/MBA	Program Manager	AJohnson@mbayaq.org	
Sarah Espinosa	UCSC	Graduate Student	smespino@ucsc.edu	
Jaqueline Lindsey	MLML	Graduate Student Researcher	jschwartzstein@mlml.calstate.edu	831-777-4422
Brent Hughes	UCSC	Capture & Handling	bbhughes@ucsc.edu	510-301-9618

8. If there has been a change in your permit status, please indicate the agency, new permit number, and permit expiration date:

   NA

Note: Any proposed changes in animal use sites, personnel, study purpose/objectives, species, animal numbers by species, or research procedures must be submitted on a Protocol Amendment Form (on the UCSC IACUC forms web page) sent to iacuc@ucsc.edu and approved by the IACUC prior to implementation of any changes.

SUBMITTED BY PRINCIPAL INVESTIGATOR

Signature of principal investigator: ____________ Date: **09/28/2017**

FINAL APPROVAL

Certification of review and approval by the UC Santa Cruz Institutional Animal Care and Use Committee:

Approval signature: ____________ Date: October 5, 2017

UCSC Live Vertebrate Animal Study – Non-Biomedical

A. ADMINISTRATIVE DATA

Submission Date: 10/14/2015		
Project Title: Population Dynamics and Biology of Sea Otters		
Principal Investigator: Tim Tinker		
Department: Biology		
Phone: 9-2357	E-mail: tinker@biology.ucsc.edu	Mail Stop: Mail Stop
Co-Respondent(s) on Protocol Communications: Carolina Dacosta cdacosta@ucsc.edu		

1. Provide the course name and number if this is a class activity.

   N/A

2. If this project is externally funded, specify the funding source and proposal number assigned by the Office of Sponsored Projects.

   USGS/U.S. Geological Survey-Western Ecological Research Center

3. List the names of all individuals authorized to conduct procedures involving animal contact under this proposal and provide their institutional affiliation, role, e-mail, and campus phone number. Add or delete rows as needed. Named individuals must complete the IACUC training course and be enrolled in Occupational Health Surveillance System (OHSS) at UCSC or at the individual's home institution. Any additional key personnel must be added by amendment prior to direct participation in the proposed activities.

Name	Affiliation	Project Role	E-mail	Phone
Tim Tinker	UCSC	PI	tinker@biology.ucsc.edu	9-2357
Carolina Dacosta	UCSC	Co-Res	cdacosta@ucsc.edu	Phone
Dr. Mike Murray	SORAC/MBA	Senior Vet/SORAC	mmurray@mbayaq,org	
Marissa Young	SORAC/MBA	Vet Technician	myoung@mbayaq.org	
Brian Hatfield	USGS	Biologist	Brian_hatfield@usgs.gov	
Joe Tomoleoni	USGS	Biologist	jtomoleoni@usgs.gov	
Ben Weitzman	USGS	Biologist	bweitzman@usgs.gov	
Jack Ames	CDFW/retired	Biologist	Jack.Ames@wildlife.ca.gov	
Mike Harris	CDFW	Biologist	Michael.D.Harris@wildlife.ca.gov	
Colleen Young	CDFW	Environmental Scientist	Colleen.young@wildlife.ca.gov	
Andrew Johnson	SORAC/MBA	Program Manager	AJohnson@mbayaq.org	
Mike Kenner	UCSC	Research Tech	mkenner@ucsc.edu	
Jaqueline Lindsey	MLML	Graduate Student Researcher	jschwartzstein@mlml.calstate.edu	831-777-4422
Brent Hughes	UCSC	Capture & Handling	bbhughes@ucsc.edu	510-301-9618

4. The CVs and emergency contact information of the PI and Co-Respondent(s) must be on file with the IACUC. Confirm that both are on file or have been submitted to iacuc@ucsc.edu.

☒ CVs on file ☐ CVs submitted ☐ Emergency contact information provided

5. **Briefly describe the qualifications of the PI and Co-Respondent(s) (if applicable) for conducting the specific procedures involving animal contact in this protocol.**

As a group, our research alliance represents hundreds of years of combined experience conducting field research on sea otters, and has contributed a large proportion of the literature published on sea otters over the past 25 years. Many of the procedures to be used in this research were developed by one or more members of this group in previous studies. Sea otter research projects involving tagged and/or instrumented animals have been conducted by members of this group in California (1969-73, 1984-86, 1987-91, 1988-92, 1998-present), the Aleutian Islands (1992-94, 1995-97, 2004-06), Prince William Sound (1989-present), SE Alaska (1997-99, 2011), the Commander Islands in Russia (2004-07), British Columbia (2011), and Washington State (1993-99, 2011).

6. **Briefly explain how the PI will ensure that personnel are properly trained and supervised for participation in specific research activities. If there are restrictions on the participation of certain personnel, briefly describe the responsibilities of each role.**

The PI will be directly responsible for ensuring the appropriate training and oversight of all personnel involved in the project. Only qualified veterinarians will perform transmitter implant surgery on sea otters. Veterinarians inexperienced in the procedure will first observe the surgery performed by an experienced veterinarian before performing the procedure him/herself. Only experienced personnel will directly participate in the capture and handling of sea otters. Less-experience personnel will initially assist with other aspects of fieldwork (i.e. field observations and data collection) and when time allows will be trained by one or more of the experienced researchers in this study in the appropriate tasks of animal capture handling (first by watching experience personnel conducting the technique, then by performing the technique under close supervision).

B. STUDY OBJECTIVES

1. **What is the purpose of this activity? (You may select more than one)**

☐ Grant/Contract ☒ Research ☐ Pilot Study ☐ Student Project ☐ Teaching ☐ Public Display
☐ Other: Please Specify

2. **Briefly explain the aim of the study and why the study is important to human or animal health, the advancement of knowledge, or the good of society in language that a layperson can understand.**

Our research over the past 15 years has provided a great deal of information on a wide range of specific cause(s) of mortality in southern sea otters (including starvation, predation, intra-specific mortality, intoxication, and a variety of infectious diseases), but much work remains to be done in order to untangle the complex web of interaction among these causal factors, and to understand the ultimate drivers of these patterns. Contrasts of diet, time-activity budgets, movements and behavioral patterns, and demography (survival and reproduction) of tagged, free-ranging otters provide the core component of our research program, allowing us to test for relationships with environmental and anthropogenic factors using a "quasi-experimental" approach. Four main types of contrasts are possible: 1) comparisons between areas of high anthropogenic impact (e.g. Monterey peninsula) and areas of low anthropogenic impact (e.g. the Big Sur coast); 2) comparisons between the center of the range (where numbers are stable or declining) and the recently occupied southern range periphery and San Nicolas Island (where numbers are increasing and where food is not a limiting factor); 3) comparisons of current data with similar data collected previously (e.g. in the 1980's at a time when the entire population was still increasing); and 4) comparisons with other regions where sea otter populations are either still growing or at equilibrium, and where similar data already exist (e.g. Southeast Alaska, Prince William Sound, the Aleutian Islands).

Blood and tissue samples collected during captures of wild otters can be incorporated into ongoing studies of sea otter disease, parasite and contaminant levels, thus providing important biomedical data for non-moribund sea otters in different parts of their range. Contrasts with existing biomedical data collected from carcasses (CDFW, unpublished data) will help define geographical patterns of disease and contaminant levels. Although our previous research has made it increasingly clear that terrestrial input of pathogen pollution is a significant part of the problem, our ability to make specific recommendations for mitigation has been hampered by uncertainty about the nature and causes of exposure. We are now pursuing more definitive information about the sources and flow of pathogen pollution inputs, and what can be done to manage risks. Our past research has also highlighted the dramatically increasing rate and significance of lethal shark bites as a driver of population dynamics. Our future studies will be designed to better understand the risk factors for shark-bite mortality, including demographic, geographic and temporal predictors as well as the potential contributions of behavior-altering conditions (e.g. intoxication from harmful algal blooms or chronic brain infections caused by protozoan parasites).

Our overall goal in CA is to identify and prioritize conservation actions that will positively affect the recovery of the southern sea otter and improve ecosystem health. In order to achieve this goal our research will address these specific objectives:

- Document patterns of mortality in the sea otter population, including spatial and temporal trends in the cause of death, and compare to equivalent patterns detectable from beach-cast carcasses
- Collect the basic data on sea otter demography, health and behavior required to refine, update and further develop population models used for advising federal and state management agencies
- Examine the inter-relationships between nutritional requirements, energetic expenditure, anthropogenic and environmental stressors, individual health and population performance

C. ANIMAL REQUIREMENTS

1. **Provide information on the target animals to be studied for the duration of the protocol (up to 3 years). If animals of the same species are to be studied in different categories (e.g., wild/captive, male/female, adult/juvenile) please list them on different rows. Add or delete rows as needed.**

Wild/Captive	Common name	Genus and species	Age and Sex	Mass range	Number requested
Wild	Southern sea otter	Enhydra lutris nereis	M/F	5-45 kg	400
Type	Common name	Genus and species	Class	Mass	Number
Type	Common name	Genus and species	Class	Mass	Number

2. **State the general geographic area(s) and specific site(s) where animal use will occur.**

   Fieldwork will occur throughout the sea otters' range in California (currently Half Moon Bay in the north to Santa Barbara in the south, including San Nicolas Island.

3. **For wild animals to be held for more than 12 hours, state how long animals will be held and describe the facility and location.**

   Enter text or N/A

4. **For long-term captive animals, state the primary housing location(s) and any other sites where animal manipulations will occur.**

   Enter text or N/A

D. RATIONALE FOR ANIMAL USE

1. **Provide a justification for animal use - explain why it is necessary to use animal models.**

   In order to study the population health, demography, behavior and ecology of wild sea otters in their natural environment, there are no alternatives to the use of live animals.

   Any alternatives to the use of live animals, or more specifically the use of wild sea otters, would not achieve the research goals (to understand population dynamics, demographics, habitat use, health profiles and energetic constraints in free living sea otters).

2. **Justify the appropriateness of the species selected, which should be the lowest possible on the phylogenetic scale.**

   The research objectives of this project are specifically directed at understanding sea otter populations in CA and addressing conservation questions about this species; no other animal species would be appropriate for this goal. Additionally, the sea otter represents an optimal sentinel (or indicator) of coastal ecosystem health, due to their sensitivity to pathogen and chemical pollution, their near-shore distribution, their extraordinary appeal to the general public (a fact which generates community support for monitoring efforts), and their tractability for observational study.

3. **Justify the number of animals to be used, which should be the minimum number required to obtain statistically valid results. Include justification for group size through a power analysis when possible.**

   A review of both the published results of past studies and of our own unpublished data sets has provided us with a fairly precise measure of the variance structure of data on population vital rates (e.g. survival, reproduction), behavior (e.g. diet and home range use) and individual health parameters (e.g. seroprevalence for various pathogens, tissue contaminant loads, etc.). Based on the observed range of values and variances, and on preliminary analyses of our existing data sets, we have proposed the minimum sample sizes sufficient (when combined with our existing samples) to obtain statistically valid results from the various analytical procedures we will conduct to achieve the objectives listed in section 10a. Over the next 3 years we will capture a total of 400 animals for flipper tagging and bio-sampling, in order to characterize basic measures of population health. Of these, we will apply surgically-implanted transmitters and bio-logging time-depth recorders (TDRs) to 220 animals, which will be used for analyses of behavior, diet, survival rates, reproduction, spatial contrasts of mortality patterns, and spatially-explicit, multifactorial epidemiological models. The total population size of the Southern sea otter at present is approximately 3,050 individuals, based on our most recent survey data. Over the next three years, demographic processes of births and deaths are expected to result in an additional 1,540 new animals and 1,417 mortalities. Our request to capture, tag, and bio-sample 400 animals over three years, assuming it is spread out as approximately 133 animals per year, represents approximately 4.2% of the total population each year, or 8.7% of a slowly growing population over the 3 year period (estimate assumes typical demographic processes).

E. DESCRIPTION OF STUDY DESIGN AND ANIMAL PROCEDURES

Briefly explain the study design and specify all animal procedures. All research procedures involving animal contact must be described with sufficient detail. This description should allow the IACUC to understand how an animal is handled from its entry into the study to the endpoint of the study. A best practice is to provide an acceptable range of the specific items described below to allow flexibility in the use of professional judgment and avoid non-compliance with the protocol. The use of each procedure should be clearly related to the study objectives. Routine animal care should be described in Section F. Surgical procedures should be separated under Section G. Details of anesthetic, analgesic, or tranquilizer drug use to alleviate pain or distress should be provided in Section H. Any departure from the <u>Guide for the Care and Use of Laboratory Animals</u> should be identified and justified.

Be sure to include the following specific information, if applicable:

- Individual animal identification methods such as visual markings, ear tags, tattoos, collars, cage cards, and implants
- Methods of capture, handling, restraint
- Procedures for animal sedation, acclimation, conditioning/training
- Parameters for sample collection (non-veterinary) such as sample type, volume, frequency, withdrawal site, and methods
- Experimental manipulations, including environmental, physical, physiological, or behavioral treatments
- Substances administered to animals including any drugs, biologics, or reagents to be used, and dosage, route, schedule
- Explanation and justification of any food or fluid restriction to be used
- Potential stressors such as noxious stimuli and procedures to monitor and minimize distress

All Study animals (400 total) will undergo one of two types of procedures: we will divide the study animals into two groups: for the first group (180 animals) we will capture, immobilize, tag and collect non-invasive samples (steps 1-3), while for the second group (220 animals) we will perform these procedures IN ADDITION TO steps 4-6 (below): these additional procedures include surgery to implant telemetry instrumentation, collection of biopsies, release for monitoring in the wild, and (whenever possible) recapture after at least 1 year in order to retrieve and/or re-implant instrumentation (steps 4-6 below). All of these procedures are described in detail below:

1. Capture of sea otters from the wild; handling and restraint; release to the wild

Individual sea otters will be captured either in tangle nets, hand-held dip nets or Wilson Traps (under water diver-held traps). All 3 methods have been used routinely in Alaska and California (e.g. Ames et al. 1983; Garshelis and Siniff, 1983; Siniff and Ralls, 1988; Estes et al. 1998). Tangle nets are surface floating, un-weighted nets set in the vicinity of sea otters. Tangle nets are typically 100m long by 5m deep with a stretch mesh of about 22 cm, but may be modified to capture in shallow water. Nets are anchored and buoyed at the float line at one or both ends. Nets are set out by a tending skiff and then monitored by the skiff and/or shore-based observers. When one or more otters become entangled in the net, the skiff returns and extracts the otter(s), transferring them to capture boxes for transport to the processing site. The nets will be set only when existing and forecast weather conditions do not preclude their being safely tended. Two shore-based observers with telescopes will monitor a deployed net, with one observer continuously scanning the float line of the net in order to detect entanglements, and the second observer scanning the entire vicinity around the net for any marine mammal activity. In the event that any non-target marine mammals are detected in the area by that second observer, the tending skiff will be called in to either pull the net or else remain beside the net until the marine mammals have left the vicinity entirely. At the time of net deployment, buoy-type floats will be attached to the float line at regular intervals (~10m apart) to increase the visibility of the float line and thus the likelihood that a shore-based observer with a telescope who was scanning that float line would be able to detect if even a small section of the net became pulled under water, signaling a possible entanglement. In such a case the tending skiff would be called in immediately to investigate (and release an entangled animal if that were the case).

Dip-netting is a procedure where sea otters are dipped out of the water with a large fish landing net. Captures are made by an individual standing in the bow of a small boat while an operator maneuvers the boat into position. This method is usually biased toward younger animals.

Our primary capture method involves using diver-operated traps to capture resting sea otters. Shore spotters with high-powered spotting scopes relay information about target animals to the dive crew. Divers work in pairs and each diver has a trap with a capacity for one adult sea otter, 2 juveniles, or a mother/pup pair. Otters must be resting (preferably sleeping) for this method to be successful. Divers use closed-circuit oxygen rebreathers and electric propulsion vehicles to maneuver the traps underneath the floating sea otters and engulf them with a net bag, which is closed by a purse line. The divers keep the animal and trap on the surface until the transport vessel arrives and the otters can be transferred to a sliding-lid capture box. Our research group has captured >600 sea otters in California, and >1000 sea otters in California, Alaska, Washington, Canada, and Russia combined, using diver operated Wilson traps with no trap-related mortalities.

Captured individuals will be transported from the capture location to the handling location in holding boxes that provide adequate ventilation. Ice or cold water will be provided as needed to keep the animals cool. Transport time will be kept to a minimum by co-locating capture vessels and handling/processing platforms. Efforts will be made to process and release sea otters within 2 hrs of capture. Trained personnel will attend each animal during all transport procedures and will monitor thermal condition and stress levels. Depending upon the nature and duration of a transport, various contingencies will be developed to ensure that animal health and comfort is maintained. In most cases animals will be brought to the research vessel or near-by land-based facility for tagging, sampling, and (in the case of animals designated for instrumentation) surgery and implantation. Animals to be flipper-tagged only may be tagged and released at the capture site. All animals will be released at or as near to their location of capture as is possible. Animals will be released to the sea only after a veterinarian has verified appropriate recovery from immobilization/tagging/surgical procedures.

We exercise best judgment and a precautionary principal when deciding which otters or groups of otters to attempt to capture. Because sea otters are difficult to capture, we often don't have the luxury of determining a specific criterion for capturing sea otters. Furthermore, enforcing a specific criterion prior to capture attempts would severely bias our research. However, shore-based spotters do have opportunity to examine prospective capture targets prior to capture attempts, and in the case of obviously moribund animals, or females with "very small pups" (see below) or groups containing previously captured animals, capture attempts will be avoided. Barring any of the above scenarios, we attempt captures on any prospective groups of resting otters, thus insuring a randomized sampling approach that is critical to nearly all scientific study design. Once an otter is captures, the decision on whether or not the otter will receive surgery or be released immediately, resides with the Chief Veterinarian, as described above. This decision is made once the otter has been transported to the veterinary station, since that is the only time a thorough examination can be done. In the past, we have occasionally noticed severely ill or moribund otters while out conducting captures. At the discretion of the lead veterinarian, and in consultation with the US Fish and Wildlife Service, we may catch these otters, not as part of our research study, but under the auspices of the Monterey Bay Aquarium's rehab permit, so that the animal can be treated by the veterinarian, or so that the veterinarian can humanely euthanize an otherwise moribund animal.

Lactating females with pups may be caught as part of this research. Our research group has a very long, successful, multi-decadal history of catching otters, including lactating females with pups. Extra care is taken when dealing with mothers and pups and they are handled carefully to minimize stress. Additionally, we avoid capturing females with extremely small pups (<3 weeks of age) to further insure the safety of both mother and pup. When a mom-pup pair with older pup is targeted, the pair is caught together in the same trap, transported together in the same transfer box (except in the situation where a pup is extremely large and 2 otters won't fit comfortably in the same box), processed and then released together so that the risk of temporary separation is extremely small. If the pup is small, a person is assigned to "pup-sit" so that the pup isn't left alone in the box while its mother is being processed by the vet team. Once the procedure is completed, the mother and pup are reunited together in the capture box, before being released together exactly where they were caught, and are monitored closely by shore teams to ensure that the pair remain together post-release.

2. Immobilization and tagging (flipper and sub-cutaneous telemetry/PIT tags)
The otters will be immobilized when necessary during handling to reduce stress to both otters and humans. In rare cases when only flipper tagging and weight measurements are to be collected, animals will be physically restrained only (without chemical immobilization) and tags will be applied at the capture boat. All animals to receive surgically implanted instrumentation will be immobilized, as will all animals to have blood or other tissues collected. Approved personnel will immobilize sea otters following slightly modified procedures to those described in Monson et al. 2001, Chemical anesthesia of northern sea otters (Enhydra lutris): results from past field studies. In this paper, the benzodiazepine, diazepam, is one of the induction agents. Diazepam is well known for its inconsistent and unpredictable absorption when administered intramuscularly. An aqueous solution of a closely related drug, midazolam, is substituted milligram for milligram. As a result, expression of the effects of fentanyl, muscle rigidity and potential seizures is prevented.

Captured sea otters will be anesthetized in sliding-lid holding boxes using a combination of fentanyl citrate and midazolam hydrochloride (F/M) and reversed with naltrexone hydrochloride (N). This combination has been used successfully for the immobilization of over 1500 sea otters of both sexes, all age classes, and in varying states of physiological and/or pathological condition. There have been no anesthetic-related mortalities associated with this immobilization protocol in field settings to date. Fentanyl/Midazolam produces smooth inductions with little or no muscle tremors or convulsions while Naltrexone provides rapid, complete reversal of the opiate, fentanyl with no risk of re-induction. The holding boxes prevent premature escape of sedated animals while providing the captured otter a calm, quiet space. The observational access provided by these capture boxes facilitate close monitoring of sea otters as induction proceeds, as well as assurance that complete reversal, including return to normal body temperature, has occurred prior to release.

Intramuscular injections of fentanyl and midazolam are administered separately with different syringes at dose rates adjusted to the purpose of handling. Darting is not used because otters are usually in the water and the risks of drowning or 'struck and loss' are too great. We use target dose rates of 0.33 mg/kg of fentanyl and 0.11 mg/kg of midazolam for surgical procedures, and 0.22 mg/kg fentanyl and 0.07 mg/kg of midazolam for non-surgical, biological sampling procedures as recommended by Monson et al. (2001). If anesthesia is not complete after approximately 15 minutes, additional fentanyl may be given. If 2-times the initial fentanyl dose is incrementally reached, and sedation is still not complete, the antagonist is given and the animal released without further handling (this is rarely observed). In the event of excessive tremors or convulsions, additional intravenous midazolam may be administered. Inhalant agents, such as isoflurane or sevoflurane, may be used as needed should anesthetic depth be deemed inadequate by the attending veterinarian. Also, based on the best judgment of the attending veterinarian, local anesthetics such as bupivacaine may be applied when potentially painful procedures are considered in the case of animals that are immobilized with lower does or when anesthetic depth be deemed inadequate.

The reversal agent Naltrexone is administered intramuscularly, at a dose equal to 2-5 times the fentanyl dose, immediately following handling. Naltrexone has a rapid onset and the initial "first response" time is typically noted within one minute. Monitoring by an experienced team member continues until reversal is complete and the animal is deemed releasable by the attending veterinarian.

In addition, sterile oxytocin (20 units/ml) may be injected intramuscularly to facilitate milk letdown in lactating females. Oxytocin, a hormone produced by the hypothalamus stimulates contraction of the smooth muscle of the mammary glands to release milk. We will only attempt to collect milk samples from females with dependent pups, no pregnant females or females without pups will be given oxytocin.

Generally all animals captured > 11 lbs will be visually tagged to prevent unintended repeated sampling of the same individuals. Each otter will be tagged with unique color/number coded polyethylene "Temple Tags" (livestock ear tags, Temple, TX) in their hind flippers (up to 3 tags per otter). Temple tags are 45 x 14 x 2 mm, and weigh ~7g. In addition to the conventional plastic temple tags, new electronic "smart tags" of comparable size and weight will be used in the future. These smart tags will be capable of collecting geolocation data and/or conducting short-distance otter-shore or otter-otter communications, and we anticipate that eventually they will replace the abdominally-implanted VHF transmitters (see below) as a less-invasive, primary means of sea otter tracking/monitoring. The form-factor and attachment method for smart tags will take one of two forms: 1) an external flipper tag similar in size and wright to the temple tags, and 2) a sub-cutaneous implantable tag of slightly larger size (6cm x 4cm x 7 mm thick) to be surgically implanted beneath the skin in the abdominal region. These smart tags would only be deployed on wild otters once enough testing has been conducted with captive otters to ensure that there is no negative response to these tags (testing will be conducted at the Monterey Bay Aquarium, and has already been approved by the Aquarium's IACUC committee). Because long-term tag retention rates are <100% (Ames et al. 1982, 1983) each sea otter may also be marked with a coded, "passive integrated transponder" or PIT tag, implanted subcutaneously in the inner thigh. PIT tags have been safely used in multiple species of all sizes, including sea otters, without deleterious effects to survival. 125 MHz tags, approximately 13 x 2mm, will be injected into the left inguinal area using a 12 gauge needle and syringe. Tag, needle, and syringe are gas-sterilized together in a package or come pre-sterilized from the manufacturer (Biomark, Boise, ID). PIT tags are encased in biocompatible glass which protects the electronics while preventing adverse effects to the animal. All captured otters will be scanned prior to initiation of sampling/external tagging for identification and to access prior capture history. When flipper-tagging, holes are punched using a sterile leather punch (hole diameter <5mm). All three types of tags described above - flipper tags, PIT tags and sub-cutaneous transmitter tags - have been used extensively in sea otter research and rehabilitation effort without any observed deleterious effects.

3. Collection of morphological/biomedical measurements and non-invasive tissue sampling
While sea otters are immobilized for tagging (as described above), a variety of morphological measurements and samples will be taken. A measurement of body weight will be taken by suspending the sea otter in a mesh bag from a hanging spring scale or placing in a tared holding box on a platform scale. Length and girth measurements are taken using a measuring tape. The paw width and the maximum diameter of the right-upper canine tooth (at gum line) are measured using standard calipers. Under the supervision of a licensed veterinarian, a broad range of biological samples would be collected from each animal for diagnostic testing and for subsequent analyses related to genetics, contaminants, endocrinology, disease, and veterinary health profiles. Samples include blood (via venipuncture, up to 5% of blood volume which is estimated to be 8% of body weight), urine (via free catch, catheterization, or cystocentesis), feces (via free-catch, manually collected per rectum, or opportunistically), microbiological cultures from nasal, rectal, oral and/or vaginal swabs, and three vibrissae, to be used for diet analysis via measurement of stable isotope ratios (vibrissae are readily extracted with a quick outward-tug). In the case of animals captured for telemetry instrumentation, a vestigial upper premolar will be extracted for age determination using standard dental elevators and forceps (Siniff and Ralls, 1988). Plugs of skin and tissue from flipper-tag punches will be retained for DNA testing and measurement of tissue contaminant levels. Milk samples will be collected opportunistically from lactating females using standardized techniques developed for marine mammals: prior to milk collection, an intra-muscular dose of oxytocin (1.0 ml of 20 IU/ml solution) will be administered, and the area around the mammary gland will be cleaned thoroughly using distilled water and dried with a clean towel. Having modified a large gauge syringe by cutting off the tapered end, the open mouth of the syringe will be placed over the nipple and, by drawing back the plunger, milk will be expressed and collected: we will attempt to collect a minimum of 1 ml and a maximum of 20 ml from each lactating female.

Additional non-invasive samples may be acquired as needed to assess health status of the subject animal. Unused samples, or extra samples acquired opportunistically during routine procedures, will be archived for future research. Any sea otter that dies will be submitted for full post-mortem evaluation to the National Wildlife Health Center in Madison, Wisconsin, the Marine Wildlife Veterinary Care and Research Center in Santa Cruz, California, or the University of California in Davis, California in accordance with schedules and protocols established by the U.S. Geological Survey.

4. Surgery, Instrumentation and Internal Sampling
All surgeries will be performed on research vessels at the capture site or at near-by land-based facilities and

will be conducted by qualified veterinarians. Two types of instrumentation will be deployed: VHF radio transmitters (80 x 22 x 50mm, ~160g, Advanced Telemetry Systems, Isanti, MN) and time depth recorders (TDRs, 67 x 17 x 17mm, ~27g, Wildlife Computers, Redmond, WA) are standard instruments that are currently surgically implanted in sea otters. Together, both instruments will represent between 0.5% (in a large male) to 2% (in a 10 kg juvenile) of body weight. Radios are potted in a waterproof electrical resin and coated with a USP Class VI material (United States Pharmacopeia, Class VI requires the most stringent testing). They transmit a radio signal allowing location of the subject animal by standard radio telemetric methods, and have an expected battery life of approximately 3 years. TDRs are potted in a hydrolytically stable material and coated with a non-bioreactive coating. Instruments are gas-sterilized and sealed in surgical steri-peal pouches for storage until used. They can record and electronically archive time-depth profiles at 2-second intervals for one year, storing these data for up to 25 years. Because sea otters exhibit distinctive dive patterns when feeding, TDR data can be used to measure the time spent foraging, length of foraging bouts, depth and duration of dives, and dive-profiles (descent/ascent velocities and time at depth). When combined with concurrent direct foraging observations (see below), these data provide a comprehensive picture of foraging behavior and effort. This procedure has been successfully completed on several hundred sea otters in Alaska and California with very low rates of mortality (< 0.2%).

VHF transmitters and TDRs are internally implanted, rather than being externally attached as in many marine mammal species, because 1) sea otters are unable to tolerate external attachments that might compromise their pelage (which is critical for thermoregulation), and 2) attached instruments similar to those used on pinnipeds would compromise their swimming and foraging abilities because of their small size. Furthermore, because of the nature of sea otter grooming activity, they are capable of reaching and removing (or destroying) most existing types of externally-attached tags.

See section 25a for detailed description of surgical technique.

5. Collection of observational and telemetric data on free-ranging animals
Monitoring of study animals by radio telemetry and direct observation is non-invasive, and causes no distress to the subjects. The researchers will regularly cover the study area, by vehicle and/or by boat, in order to gather resights of all tagged and instrumented otters: the primary purpose of this procedure is to monitor the survival, reproductive status and movement of study animals. A resight will consist of determining an otter's location by triangulation from the transmitter signal and, if possible, by making a visual sighting. Radio instrumented otters are to be located using programmable scanning receivers (Advanced Telemetry Systems, Isanti, MN), and identified using binoculars and high powered spotting scopes (Questar Corp., New Hope, PA). When an otter is located, the researcher will record its exact position as GPS coordinates. Other data recorded at each resight will include number of other otters with the subject animal, reproductive status (i.e. whether or not females have pups), behavioral state, presence or absence of a kelp canopy, water depth and distance from shore. A resight for each study animal will be obtained every 2-3 days, weather permitting. Researchers will also collect data on diet and foraging behavior by direct observation of feeding otters. In this procedure, the study animal is located (as described above) and observed using a Questar spotting scope (at 50x or 80x magnification). The data to be collected include the duration of each dive and subsequent surface time; whether or not the dive was successful; prey type; number and size of prey items caught; prey handling time, and various other information (as described in the documentation for the USGS-WERC sea otter database). Foraging data will be collected from all instrumented study animals on an opportunistic basis, although every attempt will be made to obtain roughly equivalent quantities of data from each animal, and particularly from animals with an active (i.e. data-collecting) TDR.

Data on activity budgets of study animals will be obtained by recording the behavior of a focal animal at 10 minute intervals over a 24 hour period: details of this method are provided elsewhere (Ralls and Siniff, 1990). Behavior will be recorded following the templates provided in the documentation for the USGS-WERC sea otter database.

6. Recapture of animals for retrieval of instrumentation and/or re-tagging In order to retrieve dive-profile data collected by the implanted Time-Depth Recorders (TDRs), it will be necessary to re-capture the sea otters equipped with these instruments, repeat the immobilization and surgery protocols described above (step 4) and remove the TDR instruments. These re-captures can be conducted any time after the TDRs have stopped collecting data, which will be approximately 1 year after time of deployment. VHF transmitters will typically not be removed at this time: leaving the transmitters active will allow continued monitoring of the study animals after their second release, in order to document any negative effects caused by the procedure. In the case of animals whose VHF transmitter batteries have failed and/or are nearing the end of their expected life cycles (3 years), the old transmitters will be removed and new transmitters will be implanted at this time (to allow continued monitoring). Individuals that have lost their tags may also be recaptured to be fitted with new tags. Tag replacement may occur one or more times if an animal is captured incidentally and is in need of replacement tags. If more than 6 months has elapsed since an individual was previously captured, another blood sample may be taken for longitudinal veterinary health profiles. Weaned pups that were too small to be fitted with transmitters when first captured may be recaptured to implant a transmitter. Re-captures and TDR retrievals have been conducted on sea otters in Alaska and California over the past 10 years, and monitoring of these animals post-release has indicated no apparent negative effects of the procedure (i.e. animals resumed normal feeding and behavior patterns immediately, and the survival rate for this sub-group of animals was not significantly different from that of the larger sample of animals captured only once and implanted with VHF radios).

Attached Reference Documents: Monson, DH, McCormick, C., Ballachey BE. 2003. Chemical anesthesia of northern sea otters (Enhydra lutris): Results of past field studies. Journal of Zoo & Wildlife Medicine. 32(2):181-189 Williams, T. D., A. L. Williams, et al. (1981). "Fentanyl and azaperone produced neuroleptanalgesia in the sea otter (Enhydra lutris)." Journal of Wildlife Diseases 17(3): 337-342. Williams, T. D. and D. B. Siniff (1983). "Surgical implantation of radiotelemetry devices in the sea otter." Journal of the American Veterinary Medical Association

F. ANIMAL CARE

1. **For animals to be held longer than 12 hours outside of the campus vivarium or marine mammal laboratory, briefly describe daily animal care procedures and how these activities are documented.**

   Enter text or N/A

2. **List any special considerations for housing, equipment, animal care or any departures from the Guide for Care and Use of Laboratory Animals (e.g., special caging, water, feed, waste disposal, environmental enrichment, etc.).**

   Enter text or N/A

3. **Indicate the plan of action in case of unexpected illness, morbidity, or mortality for any study animal (e.g., initiate treatment, call investigator prior to initiating treatment, contact campus veterinarian, euthanize). Note that the campus veterinarian and the IACUC must be notified immediately in the event of the unanticipated death of a study animal or non-target species during research activities unless a specific exception is identified in this protocol.**

   Enter text here

4. **Transportation of animals must conform to all institutional guidelines/policies and federal regulations. If animals will be transported outside of the primary holding facility, describe the methods and containers you will use to comply with USDA regulations.**

   Enter text or N/A

G. SURGERY

1. **Identify and describe any surgical procedure(s) to be performed. Include pre-operative procedures and monitoring and supportive care during surgery. Include the aseptic methods to be used.**

VHF transmitters and TDRs are internally implanted, rather than being externally attached as in many marine mammal species, because 1) sea otters are unable to tolerate external attachments that might compromise their pelage (which is critical for thermoregulation), and 2) attached instruments similar to those used on pinnipeds would compromise their swimming and foraging abilities because of their small size. Furthermore, because of the nature of sea otter grooming activity, they are capable of reaching and removing (or destroying) most existing types of externally-attached tags.

Consistent with sound veterinary surgical practice, abdominal surgery, including implantation of VHF and/or TDR's is done with aseptic technique. Modifications of traditional methods are necessary, however, in order to accommodate the need for immediate post-operative return to the wild and preservation of the integrity of the sea otter's pelage due to its importance in thermoregulation. Rather than shaving the fur from the surgical site, the fur overlying the ventral midline is parted with a fine-toothed comb and held in place with a combination of water soluble, sterile surgical lubricating jelly and aqueous 10% solution of povidone-iodine.

Access into the abdominal cavity is through an appropriately sized (6-10 cm) incision through the linea alba. Individually sterilized VHF transmitters and/or TDR's are then placed directly into the abdominal cavity, or in the case of TDR's may be inserted into the adipose tissue stored in the falciform ligament. If deemed necessary by the surgeon a solution of diluted antibiotic may be infused into the body cavity prior to closure.

During the course of abdominal surgeries, the veterinarian may obtain small samples (5 g or less) of liver and/or adipose tissue, using appropriate biopsy techniques. The liver may be biopsied via a laparotomy and the traditionally described guillotine method in which a ligature is placed around an appropriate liver margin, tightened, and the entrapped portion of liver excised. Minimally invasive surgical methods utilizing rigid endoscopic technology are also appropriate for smaller samples. In this technique, the peritoneal cavity is insufflated with gas, a rigid endoscopic telescope and clam-shell biopsy forceps are inserted through two aseptically placed trocar/cannulas. Under direct visualization, multiple, up to six, biopsies of the liver can be collected.

Samples of adipose tissue (fat) may be collected during routine surgical procedures as needed. These samples of up to 5 gm weight may be harvested from either the subcutis or from the falciform ligament, which typically contains large quantities of fat. Since sharp dissection and excision of fat samples is typically utilized, appropriate attention to hemostasis will be employed. Liver samples are used for analysis of contaminant exposure, while fat samples can be used for fatty acid analysis, an analytical procedure that (in conjunction with stable isotope analysis of vibrissae samples) can be used to quantify individual diets.

A multi-layer, typically consisting of 4 separate suture lines, linea alba, subcutanesous fat/muscle, subcuticular, and skin, closure is meticulously performed to assure a water-tight seal, as well as to mitigate the potential for dehiscence either due to technique or self-mutilation. A sterile, mono-filament suture which is minimally reactive, provides adequate longevity, yet is absorbed over time is used to close surgical incisions.

In addition to the process described above, additional safeguards are applied during instrument extraction/replacement surgeries. Since surgeries of this nature are more invasive with larger incisions, and greater duration, additional prophylactic measures are taken. In addition to the surgical drapes attached to the skin a secondary sterile draping system is utilized being affixed to either the subcutis or through a specialized sterile wound retractor.

A broad spectrum, extended duration antibiotic is administered in conjunction with surgery. Any significant pathology encountered intra-operatively will be investigated within the limits of the patient's well being. A record of the surgical procedure and associated findings is completed following each procedure.

2. **Identify the individual(s) that will perform surgery and their qualifications, training, and/or experience.**

   Dr. Mike Murray, DVM, Monterey Bay Aquarium

3. **Identify the facility or location where surgery will be performed.**

   Monterey Bay Aquarium surgical facilities will be used for operations close to Monterey. In other locations, surgeries will be performed in CDFW mobile veterinary units (where road access available) or a USGS-WERC research vessel (in the case of boat access only locations).

4. **If survival surgery, describe post-operative care that will be provided and frequency of observation. Identify the responsible individual(s) and location(s) where care will be provided. Include detection and management of post-operative complications during work hours, after hours, weekends and holidays.**

   After the reversal drug is administered, the attending DVM will determine that the otter is alert, responsive, and ready for release. The temperature sensitive PIT tag allows for a final temperature reading to be collected after the otter is alert, in order to ensure that body temperature is within the normal range. The otters are then released back to the original capture site as soon as possible post-surgery (once fully alert), as past experience has shown that otherwise healthy otters recover much better in the natural environment than in a captive situation. The animals are monitored closely during the release process, and immediately thereafter by shore-based observers with telescopes. to ensure a quick return to normal activity. Subsequently, attempts are made to locate each otter on a daily basis for the next 2-3 years (in rare situations we may only be able to locate specific otters 2-3 times a week if otters move to a location where shore-based access is limited), with observers paying particularly close attention to the animals health and behavior for the first 4 weeks after the surgery. Any animals that appear to be in acute distress during the first 4 weeks post-release may be re-captured for examination and treatment by a veterinarian, with such decisions made on a case-by-case basis at the discretion of the PI in consultation with a veterinarian and the US Fish and Wildlife Service. Note that the close collaboration of the PI with the Monterey Bay Aquarium (MBA) and The Marine Mammal Center (TMMC) means that there is an ability to respond to an animal in distress 7 days a week, 365 days a year.

5. **If non-survival surgery, describe how euthanasia will be provided and how death will be determined.**

   Enter text or N/A

6. **Will more than one survival surgery be performed on an animal during this study? If yes, justify.**

   Time depth recorders must be retrieved in order to download recorded data. Attempts to develop externally attached TDRs for sea otters have not been successful (to-date). Based on our past experience in Alaska and California, multiple surgeries have not resulted in additional complications or significant increased risks for study animals.

H. PAIN OR DISTRESS CLASSIFICATION AND CONSIDERATION OF ALTERNATIVES

1. Refer to pain or distress classification for USDA covered species to complete the following table, adding or deleting rows as needed. All subjects in Section C must be assigned a classification. If you are proposing Class E procedures, contact the campus veterinarian at dcasper@ucsc.edu for more information.

Species (common name)	USDA Classification (B, C, D or E)	Number of animals used each year			3 years total number of animals
		Year 1	Year 2	Year 3	
Enhydra lutris nereis	D	150	150	100	400
Species (Common name)	Class	Number	Number	Number	Number
Species (Common name)	Class	Number	Number	Number	Number
				Total number of animals	400

2. Specify any procedures that meet the criteria for Classification D.

   The methods determined to be CLASS D procedures include the surgical implantation of VHF transmitters and time-depth recorders, biopsy sampling (during surgery) and the extraction of a vestigial premolar tooth for age estimation. See section 12D for full details of these methods, and section 25 for details of surgical techniques

3. For animals assigned to Classification D, specify the anesthetics, analgesics, sedatives or tranquilizers that will be used. Include the name of the agent(s), the dosage range, route(s) and schedule of administration. Describe tracking and security of controlled drugs. For questions, contact EH&S at ehs@ucsc.edu.

Common or scientific name	**Drug**	**Dose**	**Route**	**Frequency**
Southern sea otter	Fentanyl	0.22-0.33 mg/kg	IM	Once (twice for those otters re-captured for TDR removal)
Southern sea otter	Midazolan	0.07-0.11 mg/kg	IM	Once (twice for those otters re-captured for TDR removal)
Southern sea otter	Natrexone	0.44-0.66 mg/kg	IM/IV	Once (twice for those otters re-captured for TDR removal)

4. Consideration of Alternatives

   If any procedures fall into Classification D or E, causing more than momentary or slight pain or distress to the animals, describe your consideration of alternatives and your determination that alternatives are not available. Delineate the methods and sources used in the search. Database references must include databases searched, the date of the search, and the keywords used. Alternatives include methods that (1) refine existing tests by minimizing animal distress, (2) reduce the number of animals necessary for an experiment, or (3) replace whole-animal use with *in vitro* or other tests.

   No feasible alternatives to the capture, immobilization and surgical implantation of telemetry instrumentation, or to age estimation via tooth sectioning and cementum analysis, have yet been developed for sea otters, based on our own expertise and on a review of the literature. Note: the details of the literature search results, and a full citation list of all relevant papers found, is attached to the end of this application.

I. METHOD OF EUTHANASIA OR DISPOSITION OF ANIMALS AT END OF STUDY

1. **Indicate if euthanasia is planned in the design of the study or whether it would only be considered in case an animal becomes moribund unintentionally during the course of the study. If euthanasia is not planned, describe what will be done with the remaining animals at the endpoint of the study.**

Euthanasia is not proposed or expected for this research. In the event that emergency euthanasia becomes necessary, euthanasia will be conducted by a qualified veterinarian following the protocol outlined below. Any euthanized animals, or tagged animals that die in the wild and are retrieved, will be necropsied as part of the ongoing pathology program at the CDFW and UC Davis (for which separate IACUC protocols exist).

Euthanasia will only be considered in cases of immediate relief of irreversible pain and suffering from which return to the wild is considered inhumane. Other options, including therapeutic intervention and transfer to an authorized rehabilitation facility capable of managing sea otters (ie, Monterey Bay Aquarium Sea Otter Program) will be considered prior to euthanasia. Authorization for euthanasia must be obtained from both the attending veterinarian and the permit holder.

As a result of the relatively precarious status of most sea otter populations, pre-euthanasia planning must include the collection of a variety of ante-mortem biologic samples, such as blood, urine, and potentially other tissues associated with research oversight committee-approved requests for biological samples. Additionally, preparations should be made to integrate the carcass into the necropsy database being developed under the leadership of the Marine Wildlife Veterinary Care and Research Center (MWVCRC) in Santa Cruz, CA (831-469-1719). The use of a consistent and thorough necropsy procedure results in the collection of a consistent sample set, which can then be compared to data from other sea otters.

In order to safely and humanely euthanize a sea otter, some form of chemical restraint is recommended. This immobilization facilitates the collection of appropriate biological specimens, such as blood and urine antemortem. A combination of fentanyl citrate (0.22 – 0.33 mg/kg) and midazolam or diazepam (0.07 – 0.11 mg/kg) administered intramuscularly will typically result in appropriate immobilization at the lower dose and actual anesthesia at the higher dose within 10 minutes of administration. These compounds are both controlled substances, and therefore must be handled, stored, and administered in accordance with provisions of state and federal law.

After the injection is administered, the sea otter may be transferred into a kennel, capture box, or left within the net basket until sedated. Once the otter is adequately sedated, it may be placed in dorsal recumbency for access to the vascular system for euthanasia. After ante mortem sampling has been completed, the sea otter may be euthanized with a commercially available euthanasia solution containing sodium pentobarbital (a controlled substance and managed in accordance with state and federal law) given at a rate of 1.0 ml per 2-5 kg body weight, but typically not less than 3.0 ml. In most cases, the compound is administered intravenously via the jugular veins that are easily identified on the ventro-lateral aspect of the neck between the angle of the jaw and the thoracic inlet. A wetting agent, such as isopropyl alcohol, will aid in the identification of the vessel.

Under some circumstances, direct intra-cardiac administration of euthanasia solution is preferable. Typical of the mustelids, the heart is located in the caudal aspect of the thoracic cavity, just cranial to the manubrium. As the sea otter's thorax is dorso-ventrally compressed, an apical heartbeat is generally easily visualized in the dorsally recumbent animal. An appropriately-sized needle, typically 22-20 ga 1.5-2.0 inch, may then be inserted between the ribs on either side just cranial to the site of the apical heart beat. Aspiration will confirm entry into one of the cardiac chambers, and the euthanasia solution is to be administered slowly. If no blood is recovered upon aspiration, the needle should be repositioned to assure entry into a cardiac chamber. It should be noted that the chemical characteristics of the euthanasia solution might render the heart difficult to assess during necropsy when the solution is administered via intra-cardiac route.

The very dense pelage of the sea otter is a very effective insulator, and as such cooling of sea otter carcasses to slow autolysis may be problematic. Bodies should be protected within appropriately sized plastic bags and immediately immersed in iced water or they may be placed in a freezer for 2-3 hours to accelerate cooling. Once core body temperature has reached an appropriate level, typical refrigeration is adequate.

References

1. Guidelines for Euthanasia of Nondomestic Animals. American Association of Zoo Veterinarians, 2006.

2. Guidelines for Zoo and Aquarium Veterinary Medical Programs and Veterinary Facilities. American Association of Zoo Veterinarians, 1999.

3. Burns RB, McMahan W: Euthanasia methods for ectothermic vertebrates. In: Bonagura J (ed). Current Veterinary Therapy XII. WB Saunders Co, Philadelphia, PA, 1995, 1379-1381.

4. Reilly JS. Euthanasia of animals used for scientific purposes. "Australian and New Zealand Council for the Care of Animals in Research and Teaching.", 2nd ed, 2001: 85-86

2. **If euthanasia is planned, specify the method and the individual(s) responsible for performing euthanasia techniques. If a chemical agent is used, specify the dosage range and route(s) of administration. If the method(s) of euthanasia include those not recommended by the AVMA Guidelines on Euthanasia, provide scientific justification as to why such methods must be used. Specify the method of carcass disposal if not described in Section L below.**

   Euthanasia is not planned

J. COLLECTION OF VERTEBRATE SAMPLES

1. **List any samples to be collected for the study, including common and scientific names of species and sample types. Diagnostic samples obtained for veterinary use only need not be included here. If permit(s) are required, please provide details in Section K.**

List of samples to be taken from live captured or dead sea otters, Enhydra lutris, during the course of this study:

Sample Type	Live/Carcass	Amount Collected	Use	Comments
Blood	Live	5% blood volume (blood volume = 8% BW	Hematology, clinical chemistry, infectious disease monitoring, biomarkers, contaminants	Blood volume "lost" from animal to include collection, loss to hematoma, bleeding from tagging, and surgical bleeding
External swabs (integument, oral cavity, rectum, genital orifice	Live	No volume limitation	Infectious disease (bacterial, fungal, parasitic, viral), contaminants, genetics	
Saliva	Live	0.3 - 1.0 ml	Hormonal assays	
Feces	Live	No limit	Diet assessment, infectious disease (bacterial, fungal, parasitic, viral), contaminants, biotoxin, hormonal assay	From environment
	Live	< 100gm		Collected from rectum
Milk	Live	< 10 ml	Nutritional content, fatty acid analysis, contaminants	May require administration of oxytocin to cause release
Urine	Live	TBD by DVM	Infectious disease, toxins, urinalysis, contaminants	Free catch or cystocentesis
Adipose tissue	Both	< 10 gm (live)	Fatty acids, contaminants	May require surgical intervention with appropriate consideration for anesthesia and surgical methodology.
		No limit (dead)		
External pathology (integument, oral cavity, genital orifice)	Both	TBD by DVM	Histopathology, genetics, etiopathogenetic investigation	May require surgical intervention with appropriate consideration for anesthesia and surgical methodology.
Liver biopsies	Both	< 2 gm (live)	Histopathology, toxicology, contaminants, genetics, chemical analysis (ie, Vit A analysis)	May require surgical intervention with appropriate consideration for anesthesia and surgical methodology.
		No limit (dead)		Collected at necropsy
Premolar tooth	Both	1	Cementum aging	First upper premolar, only
Skin plugs	Both	< 2 gm (live)	Genetics	Collected in association with flipper tagging in live animals
Vibrissae	Both	2	Stable isotope	
Baculum	Carcass	1	Morphometrics, stable/radio isotopes	
Tooth	Carcass	No limit (dead)	Cementum aging	
Skull	Carcass	1 or portions	Morphometrics, stable/radio isotopes	
Fur	Both	NMT 1 gm	Hormonal assays, toxins, contaminants	Collected by plucking as not to interfere with thermoregulation.

2. Describe why the samples or specimens are needed, how these materials are to be collected, or indicate whether and how they will be received from others for use in this activity.

The table above explains the reasons for collecting the samples from live captured or dead sea otters. The following describes the methods for collecting material or measurements. While sea otters are immobilized for tagging (as described above), a variety of morphological measurements and samples (see table above) will be taken. A measurement of body weight will be taken by suspending the sea otter in a mesh bag from a hanging spring scale or placing in a tared holding box on a platform scale. Length and girth measurements are taken using a measuring tape. The paw width and the maximum diameter of the right-upper canine tooth (at gum line) are measured using standard calipers. Under the supervision of a licensed veterinarian, a broad range of biological samples would be collected from each animal for diagnostic testing and for subsequent analyses related to genetics, contaminants, endocrinology, disease, and veterinary health profiles. Samples include blood (via venipuncture, up to 5% of blood volume which is estimated to be 8% of body weight), urine (via free catch, catheterization, or cystocentesis), feces (via free-catch, manually collected per rectum, or opportunistically), microbiological cultures from nasal, rectal, oral and/or vaginal swabs, and three vibrissae, to be used for diet analysis via measurement of stable isotope ratios (vibrissae are readily extracted with a quick outward-tug). In the case of animals captured for telemetry instrumentation, a vestigial upper premolar will be extracted for age determination using standard dental elevators and forceps (Siniff and Ralls, 1988). Plugs of skin and tissue from flipper-tag punches will be retained for DNA testing and measurement of tissue contaminant levels. Milk samples will be collected opportunistically from lactating females using standardized techniques developed for marine mammals: prior to milk collection, an intra-muscular dose of oxytocin (1.0 ml of 20 IU/ml solution) will be administered, and the area around the mammary gland will be cleaned thoroughly using distilled water and dried with a clean towel. Having modified a large gauge syringe by cutting off the tapered end, the open mouth of the syringe will be placed over the nipple and, by drawing back the plunger, milk will be expressed and collected: we will attempt to collect a minimum of 1 ml and a maximum of 20 ml from each lactating female.

If any of the above samples are taken post-mortem, they will be from sea otter carcasses that are recovered by a member of our team or collaborators (in particular, MBA or California Department of Fish and Wildlife). These are carcasses that either wash up on beaches or are discovered floating offshore. Carcasses are recovered throughout the entire range of the Southern sea otter as part of the US Fish and Wildlife mandated stranding response program, which encompasses all areas from Half Moon Bay to Santa Barbara, though occasionally carcasses will wash up outside the normal range of this species. Field necropsies or a complete lab necropsy (in the case of all tagged study animals) are conducted by a veterinary pathologist at the California Department of Fish and Wildlife, and samples are collected during necropsy. These samples may be used for research processes, but are also used by the pathologist to help determine cause of death for study animals: detailed reports from necropsies and associated sample analyses are provided to the US Fish and Wildlife Service Division of Management Authority, as required under the terms of our federal permit.

3. Researchers working on unfixed tissues of primates and wild animals may be exposed to pathogens such as Hantavirus, hepatitis-B, and herpesvirus Simiae. Please indicate below whether your work involves specimens that may carry pathogens, or if you are working with specimens with little or no medical history. If so, contact biosafety@ucsc.edu.

☒ N/A ☐ Use of Potentially Hazardous Tissues ☐ Contacted biosafety@ucsc.edu

K. RESEARCH AUTHORIZATIONS

1. **Is another IACUC involved in this activity? If so, provide explanation and contact information for the IACUC.**

   U.S. Geological Survey-Western Ecological Research Center (USGS-WERC)
   Marine Wildlife Veterinary Care and Research Center (MWVCRC) of Cal. Dept. Fish & Wildlife, the Monterey Bay Aquarium, and the Wildlife Health Center at the School of Veterinary Medicine at University of California -Davis (see section A for contact info)

   All field captures of wild otters and field data collection (telemetry and observational work) are to be covered under this IACUC. Monterey Bay Aquarium, MWVCRC and UC Davis all have IACUC permits to cover their components of sea otter studies (including transport, archiving and analysis of all tissues collected at capture, etc.).

2. **Indicate if federal, state, and/or local permits are required and whether they have been obtained or applied for. Provide the agency, number, and expiration date for each authorization. Be advised that while IACUC approval may be granted prior to permit acquisition, no animal use activities can occur without both IACUC and required agency authorizations. The IACUC may request copies of these authorizations at any time. Add additional rows if needed.**

Agency	Permit number or ID	Expiration	Application status/comment
US Fish and Wildlife Service	MA672624-18	9/12/2018	Current/active permit

L. HEALTH AND SAFETY CONSIDERATIONS

1. **The use of hazardous substances, equipment, or procedures may require special approval from UCSC Environmental Health & Safety, Institutional Biosafety Committee, and/or the Radiation Safety Committee. Indicate whether you are using any of the following substances in your research. If so, identify the substance(s) and provide status of your usage permissions. Relevant links are provided in the table below.**

Substance	Contact	Agent(s)	Authorization Status
☐ Biological Agents	IBC	Agent(s)	None, Pending, or Approved
☐ Recombinant DNA	IBC	Agent(s)	None, Pending, or Approved
☐ Hazardous Chemicals	EH&S	Agent(s)	None, Pending, or Approved
☒ Controlled Drugs	EH&S	Fentanyl used by veterinarian to immobilize animals	Use by MBA Veterinarian has been approved by relevant agencies
☐ Radionucleotides	RSC	Agent(s)	None, Pending, or Approved

2. **Describe the practices and procedures required for the safe handling and disposal of animal tissues and material associated with this study. Also describe methods for removal of radioactive or hazardous waste.**

   N/A

3. **Indicate any potentially hazardous equipment, procedures, or operations (e.g., firearms, power tools, rock climbing, scientific diving, work in confined spaces, etc.) and what measures will be taken to control or mitigate hazards.**

   Scientific diving is frequently used to capture sea otters for tagging, to obtain biological samples, and/or for instrumentation. The divers are trained and certified on oxygen rebreathers for this work and follow protocols developed over several decades of this work.

4. Field Operational Plans (FOP) are required for fieldwork (off-campus outdoor research, teaching, or learning activity) or any activity to take place outside of the United States. If these activities are anticipated, indicate below and contact the EH&S Advisor at 831-459-5182 or jamess@ucsc.edu.

   ☐ N/A ☒ Fieldwork ☐ International Travel ☒ Contacted EH&S Advisor ☒ Completed FOP

M. PRINCIPAL INVESTIGATOR CERTIFICATIONS

☒ I certify that I will notify the IACUC regarding any unexpected study results that impact the animals. Any unanticipated pain or distress, morbidity or mortality will be reported to the attending veterinarian and the IACUC.

☒ I certify that I have determined that the research proposed herein is not unnecessarily duplicative of previously reported research.

☒ I certify that I have completed the CITI investigator training course required by the IACUC.

☒ I certify that I am aware that all individuals working on this proposal who are at risk are required to participate in the institution's Occupational Health and Safety Program.

☒ I certify that I am aware that all individuals working on this protocol are required to attend the CITI investigator training course, and have received training appropriate to their role, such as: the biology, handling, and care of this species; aseptic surgical methods and techniques; the concept, availability, and use of research or testing methods that limit the use of animals or minimize distress; the proper use of anesthetics, analgesics, and tranquilizers; and procedures for reporting animal welfare concerns.

☒ I certify that either no procedures will be performed which may cause more than momentary pain or distress OR that I have reviewed the pertinent scientific literature and/or databases and have found no valid alternative to any Classification D and/or E procedures described herein.

☒ I certify that I will obtain approval from the IACUC before initiating any significant changes in this study.

☒ I certify that I am familiar with and will comply with all pertinent institutional, state, and federal rules and policies.

* Questions, suggestions, or feedback regarding this form should be directed to iacuc@ucsc.edu

Submitted by Principal Investigator

Name: M. Tim Tinker **Date:** 10/14/2015

FINAL APPROVAL

Certification of review and approval by the Institutional Animal Care and Use Committee:

Approval Signature: Date: 12/15/2015

Appendices

A) Results from Literature Search and List of Relevant Literature on sea otter field research procedures

Search Results:

Terms	BIOSIS	Web of Science	# relevant to proposed research
keyword **sea otter** [and] keyword **capture**	29	21	14
keyword **sea otter** [and] keyword **immobilization**	3	1	4
keyword **Neuroleptanalgesia** [and] keyword **immobilization**	6	5	1
keyword **alternatives** [and] keyword **immobilization** [and] keyword **carnivore**	8	1	1
keyword **otter** [and] keyword **age estimation**	3	3	3
keyword **alternatives** [and] keyword **age estimation** [and] keyword **carnivore**	0	0	0
keyword **otter** [and] keyword **telemetry**	18	30	12

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(version: Jan2010)

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Williams, TM and L Yeates (2005). "The energetics of foraging in large mammals: a comparison of marine and terrestrial predators." International Congress Series **1275: 351-358.**

UCSC Institutional Animal Care and Use Committee (IACUC)
Phone 831-459-3150 | Fax 831-459-1452
E-mail iacuc@ucsc.edu | Mail Stop - Office of Research

Proposal Code: **TINKT1510_A1**
Approval Date: ADMIN USE ONLY
Expiration Date: ADMIN USE ONLY

UCSC Animal Use Protocol Amendment

Submission Date: 7/6/2016		
Project Title: "Population Dynamics and Biology of Sea Otters" Tinkt1306		
Principal Investigator: M. Tim Tinker		
Department: EE Biology		
Phone: 459-2357	E-mail: ttinker@ucsc.edu	Mail Stop: LML/COH Bldg
Co-Respondent(s) on Protocol Communications: Carolina DaCosta, cdacosta@ucsc.edu		

A. PERSONNEL AMENDMENT (ADMINISTRATIVE REVIEW ONLY)

1. List the names of any additional individuals who wish to conduct procedures involving animal contact under this proposal and provide their institutional affiliation, role, e-mail, and campus phone number.

   Add or delete rows as needed. Named individuals must complete the IACUC training course and be enrolled in Occupational Health Surveillance System (OHSS) at UCSC or at the individual's home institution. Any additional key personnel must be added by amendment prior to direct participation in the proposed activities.

Name	Affiliation	Project Role	E-mail	Phone
Michael Haslam	University of Oxford	Visiting collaborator	michael.haslam@arch.ox.ac.uk	+44 (0)7884 414354
Natalie Uomini	Max Planck Institute	Visiting collaborator	uomini@shh.mpg.de	+49-177-393-0323
Tracy Grimes	San Diego State U.	Collaborating grad st.	tgrimes0819@gmail.com	(951) 858-7379

2. Briefly explain how the PI will ensure that personnel are properly trained and supervised for participation in specific research activities. If there are restrictions on the participation of certain personnel, briefly describe the responsibilities of each role.

   The three above-names personnel will not participate in direct handling of live animals (capture and tagging) but will participate in observational data collection in the field following the approved protocols for collecting behavioral data from tagged sea otters. Prior to collecting data they will be trained by the PI and by other experienced field biologists named on the above protocol, to ensure they are fully compliant with all procedures set in place to avoid any disturbance to the study animals, or incidental disturbance to other wildlife, during data collection activities.

B. PROTOCOL AMENDMENT FOR ALL OTHER CHANGES (IACUC REVIEW)

1. If you have applied for or received funding through UCSC's Office of Sponsored Projects and have not yet reported it to the IACUC, specify the funding agency and Cayuse project number.

   Enter text here

2. Propose any changes in animal use sites.

   Enter text here

3. Specify any new permits. Be sure to include the permit agency, permit numbers, and permit expiration dates.

   Enter text here

4. Propose any changes in purpose or objectives.

   Enter text here

5. Propose any changes in animals used. Specify changes in species and animal numbers (by species), and provide basis for the proposed changes.

   Enter text here

6. Propose any changes in procedures to be used on animals. Describe the procedures in detail and specify their anticipated effect on the animals. USDA Classification D and E procedures require updated literature review for consideration of alternatives and new Classification E procedures require consultation with the campus veterinarian (dcasper@ucsc.edu).

   Enter text here

The PI certifications from the associated protocol apply fully to any changes proposed on this form.

* Questions, suggestions, or feedback regarding this form should be directed to iacuc@ucsc.edu

Submitted by Principal Investigator

Name: Name Date: Date

FINAL APPROVAL

Certification of review and approval by the Institutional Animal Care and Use Committee:

Approval Signature: Date: 7/8/2016

Mike Kenner <mkenner@ucsc.edu> Fri, Nov 18, 2016 at 2:15 PM
To: Tim Tinker <ttinker@ucsc.edu>, IACUC <iacuc@ucsc.edu>
Cc: Joe Tomoleoni <jtomoleoni@usgs.gov>, Carolina Dacosta <cdacosta@ucsc.edu>

If you are the co-respondent, not the PI, enter the PI's e-mail address in 'Cc' line of header.

ENTER 'NA' IF ANY ITEM BELOW DOES NOT APPLY:

1. Were animals used since your last annual update (or initial approval if protocol is in its first year? **Yes**

2. If not animals were used, state reason:

3. If animal use is complete and will not resume, you are finished. Hit SEND.

3. Is animal use active and expected to continue past the anniversary date? **Yes**

4. If currently inactive, is animal use expected to resume? If so, approximate date?

5. If animal use is active, or may resume, respond to the following. Enter 'NA' is any item does not apply:

6. Specify by species animal numbers used since last update (or initial approval if protocol is in first year): **34 *Enhydra lutris* captured (25 of these underwent surgery for instrumentation)**

7. Specify by species animals remaining (total approved less total used since initial approval): **366 *Enhydra lutris*, 195 of which may be instrumented**

8. If you have applied for, or received, funding through the UCSC Office of Sponsored Projects that you have not yet reported to IACUC, specify the funding agency and OSP data sheet SC#. Failure to do so will delay distribution of any grant funds:

9. List all personnel approved to work on this protocol (EH&S will follow-up on occupational health program status):

Name	Affiliation	Project Role
Tim Tinker	UCSC	PI
Carolina Dacosta	UCSC	Co-Res
Dr. Mike Murray	SORAC/MBA	Senior Vet/SORAC
Marissa Young	SORAC/MBA	Vet Technician
Brian Hatfield	USGS	Biologist
Joe Tomoleoni	USGS	Biologist
Ben Weitzman	USGS	Biologist
Jack Ames	CDFW/retired	Biologist
Mike Harris	CDFW	Biologist
Colleen Young	CDFW	Environmental Scientist
Andrew Johnson	SORAC/MBA	Program Manager
Mike Kenner	UCSC	Research Tech
Jaqueline Lindsey	MLML	Graduate Student

Brent Hughes	UCSC	Researcher Capture & Handling	bbhughes@

10. If there has been a change in your permit status, please indicate the agency, new permit number, and permit expiration date.

Please take a moment to consider review your animal care and use protocol and assess whether you will require any changes in animal use sites, personnel, study purpose/objectives, species, animal numbers by species, or research procedures. Any such changes must be requested on a simple protocol amendment form available at: http://officeofresearch.ucsc.edu/orca/iacuc/IACUC%20Forms.html. Amendment forms should be submitted to iacuc@ucsc.edu and must be approved by the IACUC prior to implementation of any changes.

11. Do you need to submit a protocol amendment form at this time? **No**

UC Santa Cruz Institutional Animal Care and Use Committee (UCSC IACUC)
Phone: (831) 459-3150 | Fax: (831) 459-1452
Email: iacuc@ucsc.edu | Mail stop: Office of Research

Proposal Code: Tinkt1510_r2
Approval Date: October 5, 2017

Annual Protocol Update

Please fill out this form completely and send to iacuc@ucsc.edu. Enter N/A where not applicable. Questions and feedback regarding this form should be directed to iacuc@ucsc.edu.

In accordance with federal law, if an update is not approved by the anniversary date, December 15, 2017, all animal use activity under this protocol must stop and a new protocol application must be submitted and approved by the IACUC.

Submission date: 09/28/2017		
Project title: Population Dynamics and Biology of Sea Otters		
Principal investigator: Tim Tinker		
Department: Biology		
Phone: (831) 459-2357	Email: ttinker@ucsc.edu	Mail stop: LML
Co-respondent(s) on protocol communications: Michael Kenner mkenner@ucsc.edu		

1. Were animals used since your last annual update (or initial approval if protocol is in its first year)?

   Yes

2. If no animals were used, state reason (if animal use is complete and will not resume, you are finished):

   NA

3. If currently inactive, is animal use expected to resume? If so, approximate date? (if no, you are finished):

   NA

4. Specify by species animal numbers used since last approval or update:

   8 *Enhydra lutris* captured (2 of these underwent surgery for instrumentation)

5. Specify by species animals remaining (total approved less total used since initial approval):

   358 *Enhydra lutris*, 193 of which may be instrumented

6. If you have applied for funding through the UCSC Office of Sponsored Projects that you have not yet reported to UCSC IACUC, specify the funding agency and OSP Cayuse #. Failure to do so will delay distribution of any grant funds:

   NA

7. List all personnel approved to work on this protocol:

Name	Affiliation	Project Role	E-mail	Phone
Tim Tinker	UCSC	PI	tinker@biology.ucsc.edu	9-2357
Mike Kenner	UCSC	Co-Res	mkenner@ucsc.edu	254-5184
Dr. Mike Murray	SORAC/MBA	Senior Vet/SORAC	mmurray@mbayaq.org	
Marissa Young	SORAC/MBA	Vet Technician	myoung@mbayaq.org	
Brian Hatfield	USGS	Biologist	Brian_hatfield@usgs.gov	
Joe Tomoleoni	USGS	Biologist	jtomoleoni@usgs.gov	

Ben Weitzman	USGS	Biologist	bweitzman@usgs.gov	
Jack Ames	CDFW/retired	Biologist	Jack.Ames@wildlife.ca.gov	
Mike Harris	CDFW	Biologist	Michael.D.Harris@wildlife.ca.gov	
Colleen Young	CDFW	Environmental Scientist	Colleen.young@wildlife.ca.gov	
Andrew Johnson	SORAC/MBA	Program Manager	AJohnson@mbayaq.org	
Sarah Espinosa	UCSC	Graduate Student	smespino@ucsc.edu	
Jaqueline Lindsey	MLML	Graduate Student Researcher	jschwartzstein@mlml.calstate.edu	831-777-4422
Brent Hughes	UCSC	Capture & Handling	bbhughes@ucsc.edu	510-301-9618

8. If there has been a change in your permit status, please indicate the agency, new permit number, and permit expiration date:

   NA

Note: Any proposed changes in animal use sites, personnel, study purpose/objectives, species, animal numbers by species, or research procedures must be submitted on a Protocol Amendment Form (on the UCSC IACUC forms web page) sent to iacuc@ucsc.edu and approved by the IACUC prior to implementation of any changes.

SUBMITTED BY PRINCIPAL INVESTIGATOR

Signature of principal investigator: ________ Date: **09/28/2017**

FINAL APPROVAL

Certification of review and approval by the UC Santa Cruz Institutional Animal Care and Use Committee:

Approval signature: ________ Date: October 5, 2017

Proposal Code: Tinkt1510_a3_p
Approval Date: Feb. 6, 2018

Protocol Amendment

Please fill out this form completely and send to iacuc@ucsc.edu. Enter N/A where not applicable. Questions and feedback regarding this form should be directed to iacuc@ucsc.edu.

Submission date: 02/05/2018		
Project title: Population Dynamics and Biology of Sea Otters		
Principal investigator: Tim Tinker		
Department: Biology		
Phone: (831) 459-2357	Email: ttinker@ucsc.edu	Mail stop: LML
Co-respondent(s) on protocol communications: Michael Kenner mkenner@ucsc.edu		

A. PERSONNEL AMENDMENT (ADMINISTRATIVE REVIEW ONLY)

1. List the names of any additional individuals who wish to conduct procedures involving animal contact under this proposal and provide their institutional affiliation, role, email, and campus phone number. Add or delete rows as needed. Named individuals must complete the IACUC training course and be enrolled in Occupational Health Surveillance System (OHSS) at UCSC or at the individual's home institution. Any additional key personnel must be added by amendment prior to direct participation in the proposed activities.

Name	Affiliation	Project Role	Email address	Phone	Non-affiliated personnel certification*
Joe Tomoleoni	USGS	Co-respondent	jtomoleoni@usgs.gov	(831) 254-9750	X

*PI certifies that non-affiliated individuals have completed animal care and use training and occupational health and safety assessment at the individual's home institution.

2. Briefly explain how the PI will ensure that personnel are properly trained and supervised for participation in specific research activities. If there are restrictions on the participation of certain personnel, briefly describe the responsibilities of each role.

   Joe Tomoleoni is already listed as a biologist on the existing protocol. He has over a decade of experience capturing, handling and observing sea otters. This amendment merely adds him as a co-respondent.

B. PROTOCOL AMENDMENT FOR ALL OTHER CHANGES (IACUC REVIEW)

1. If you have applied for or received funding through UCSC's Office of Sponsored Projects and have not yet reported it to the IACUC, specify the funding agency and Cayuse project number.

   NA

2. Propose any changes in animal use sites.

   NA

3. Specify any new permits. Be sure to include the permit agency, permit numbers, and permit expiration dates.

   NA

4. Propose any changes in purpose or objectives.

   NA

5. Propose any changes in animals used. Specify changes in species and animal numbers (by species), and provide basis for the proposed changes. More information about animal numbers on UCSC IACUC FAQs web page.

NA

6. Propose any changes in procedures to be used on animals. Describe the procedures in detail and specify their anticipated effect on the animals. Use related reference USDA Classifications on the UCSC IACUC forms web page to determine whether your procedures meet USDA Classification D and E; Classification D and E procedures require updated literature review for consideration of alternatives and new Classification E procedures require consultation with the campus veterinarian (dcasper@ucsc.edu) and completion of the Class E Justification Form on the UCSC IACUC forms web page.

   NA

The PI certifications from the associated protocol apply fully to any changes proposed on this form.

SUBMITTED BY PRINCIPAL INVESTIGATOR

Signature of principal investigator: ______________ Date: 02/05/2018

FINAL APPROVAL

Certification of review and approval by the UC Santa Cruz Institutional Animal Care and Use Committee:

Approval signature: ______________ Date: February 6, 2018

Relevant Sea Otter Publications resulting from prior versions of MA672624

Fujii, J.A., Ralls K, **Tinker M.T.** (2017) Food abundance, prey morphology, and diet specialization influence individual sea otter tool-use. Behavioral Ecology, 28(5), 1206-1216. doi:https://doi.10.1093/beheco/arx011

Ralls K, Rotzel McInerney N, Gagne RB, Ernest HB, **Tinker MT, Fujii J**, Maldonado J. 2017. Mitogenomes and relatedness do not predict frequency of tool use by sea otters. Biology Letters13 (3), 20160880

Tinker, M. T., J. Tomoleoni, N. LaRoche, L. Bowen, A. K. Miles, M. Murray, **M. Staedler**, and **Z. Randell**. 2017. Southern sea otter range expansion and habitat use in the Santa Barbara Channel, California. USGS Open File Report 2017-1001, Reston, VA.

Breed, G. A., **E. A. Golson** and **M. T. Tinker**. 2017. Predicting animal home range structure and transitions using a multistate Ornstein-Uhlenbeck biased random walk. Ecology,98(1), 32-47. Doi:10.1002/ecy.1615

Thometz, N.M., Staedler, M.M., Tomoleoni, J.A., Bodkin, J.L., **Bentall, G.B., Tinker, M.T.** 2016. Trade-offs between energy maximization and parental care in a central place forager, the sea otter. Behavioral Ecology, 27(5): 1552-1566

Tinker, M.T., Staedler, M.M., Tarjan, L.M., Bental, G.B., Tomoleoni, J.A., and LaRoche, N.L., 2016, Geospatial data collected from tagged sea otters in central California, 1998-2012: U.S Geological Survey data release, http://www.dx.doi.org/10.5066/F76H4FH8.

Tarjan, L.M., and M. T. Tinker. 2016. Permissible Home Range Estimation (PHRE) in Restricted Habitats: A New Algorithm and an Evaluation for Sea Otters. PLoS One

Chinn, S. M., M. A. Miller, **M. T. Tinker, M. M. Staedler**, F. I. Batac, **E. M. Dodd**, L. A. Henkel. 2016. The High Cost of Motherhood: End-Lactation Syndrome in Southern Sea Otters. Journal of Wildlife Diseases, 52(2):307-318. doi: 10.7589/2015-06-158

Tinker, M.T., B. B. Hatfield, M. D. Harris, and J. A. Ames. 2015. Dramatic Increase in Sea Otter Mortality from White Sharks in California. Marine Mammal Science, 32(1): 309–326,

Novak, M. and **M.T. Tinker**. 2015. Time-scales alter the inferred strength and temporal consistency of intraspecific diet specialization. Oecologia 178:61–74

Newsome, S.D., **M.T. Tinker**, V.A. Gill, Z.N. Hoyt, A. Doroff, L. Nichol, and J.L. Bodkin. 2015. The interaction of intraspecific competition and habitat on individual diet specialization: a near range-wide examination of sea otters. Oecologia, 178: 45-59

Smith, E.A.E., S.D. Newsome, **J.A. Estes and M.T. Tinker**. 2015. The cost of reproduction: differential resource specialization in female and male California sea otters. Oecologia, 178:17-29

Fujii, J. A., K. Ralls, and **M. T. Tinker**. 2015. Ecological drivers of variation in tool-use frequency across sea otter populations. Behavioral Ecology, 26(2) 519-526

Bowen, L., A. K. Miles, C. A. Kolden, J. A. Saarinen, J. L. Bodkin, M. J. Murray, and **M. T. Tinker**. 2014. Effects of wildfire on sea otter (Enhydra lutris) gene transcript profiles. Marine Mammal Science, 31(1):191–210

Lafferty, K.D. and **Tinker, M.T**. 2014. Sea otters are recolonizing southern California in fits and starts. Ecosphere (Ecological Society of America) 5:art50

Thometz, N. M, Tinker, M. T., Staedler, M.M., Mayer, K.A., and Williams, T.M. 2014. Energetic Demands of Immature Sea Otters from Birth to Weaning: Implications for maternal costs, reproductive behavior, and population level trends. Journal of Experimental Biology 217, 2053-2061

Kenner, M. C., **J. A. Estes, M. T. Tinker**, J. L. Bodkin, R. K. Cowen, C. Harrold, B. B. Hatfield, M. Novak, A. Rassweiler, and D. C. Reed. (*in press*) A multi-decade time series of kelp forest community structure at San Nicolas Island, California. Ecology.

Hughes, B. B., R. Eby, E. Van Dyke, **M. T. Tinker**, C. I. Marks, K. S. Johnson, and K. Wasson. 2013. Recovery of a top predator mediates negative eutrophic effects on seagrass. Proceedings of the National Academy of Sciences. doi:10.1073/pnas.1302805110

Oates, S.C., Miller, M.A., Hardin, D., Conrad, P.A., Melli, A., Jessup, D.A., Dominik, C., Roug, A., **Tinker, M.T.,** Miller, W.A. 2012. Prevalence, Environmental Loading, and Molecular Characterization of Cryptosporidium and Giardia Isolates from Domestic and Wild Animals along the Central California Coast. Applied and Environmental Microbiology. 78(24): 8762–8772

Tinker M.T., Guimarães P.R., Novak M., Marquitti F.M.D., L. B.J., Staedler M., Bentall G. & **J.A. Estes**. 2012. Structure and mechanism of diet specialization: testing models of individual variation in resource use with sea otters. Ecology Letters 15(5) 475-483.

Bowen L., Miles A.K., Murray M., Haulena M., Tuttle J., Van Bonn W., Adams L., Bodkin J.L., Ballachey B., Estes J., **Tinker M.T.**, Keister R. & Stott J.L. 2012. Gene transcription in sea otters (Enhydra lutris); development of a diagnostic tool for sea otter and ecosystem health. Molecular Ecology Resources 12:67-74.

Kim SL, **Tinker MT**, **Estes JA**, Koch PL. 2012. Ontogenetic and Among-Individual Variation in Foraging Strategies of Northeast Pacific White Sharks Based on Stable Isotope Analysis. PLoS ONE 7(9): e45068. doi:10.1371/journal.pone.0045068

Newsome, Seth D., Justin D. Yeakel, Patrick V. Wheatley, **M. Tim Tinker**. 2012. Tools for quantifying isotopic niche space and dietary variation at the individual and population level. Journal of Mammalogy 93(2), 329-341.

Estes, J.A. J. Terborgh, J. S. Brashares, M.E. Power, J. Berger, W. J. Bond, S. R. Carpenter, T. Essington, R. D. Holt, J. B.C. Jackson, R. J. Marquis, L. Oksanen, T. Oksanen, R. T. Paine, E. K. Pikitch, W. J. Ripple, S. A. Sandin, M. Scheffer, T. W. Schoener, J. B. Shurin, A. R.E. Sinclair, M. E. Soulé, R. Virtanen, and D. A. Wardle. 2011. Trophic downgrading of planet earth. Science 333:301-306

Watson, J. and **J.A. Estes.** 2011. Stability, resilience, and phase shifts in kelp forest communities along the west coast of Vancouver Island, Canada. Ecological Monographs 81:215-239.

Hatfield, B.B., J.A. Ames, **J.A. Estes**, **M.T. Tinker**, E.B. Johnson, **M.M. Staedler**, and M.D. Harris. 2011. Sea otter mortality in fish and shellfish traps: estimating potential impacts and exploring possible solutions. Endangered Species Research 13:219-229.

Novak, M., J.T. Wootton, D.F. Doak, M. Emmerson, **J.A. Estes**, and **M.T. Tinker**. 2011. Predicting community responses to perturbations in the face of imperfect knowledge and network complexity. Ecology 92:836-846.

Harris, Heather S., Stori C. Oates, **Michelle M. Staedler**, **M. Tim Tinker**, David A. Jessup, James T. Harvey, and Melissa A. Miller. 2010. Behavior Associated with Forced Copulation of Juvenile Pacific Harbor Seals (*Phoca vitulina richardsi*) by Southern Sea Otters (*Enhydra lutris nereis*). Aquatic Mammals 36(4): 219-229.

Miller, Melissa A., Raphael M. Kudela, Abdu Mekebri, Dave Crane, Stori C. Oates, **M. Timothy Tinker**, **Michelle Staedler**, Woutrina A. Miller, Sharon Toy-Choutka, Clare Dominik, Dane Hardin, Gregg Langlois, Michael Murray, Kim Ward, David A. Jessup. 2010. Evidence for a Novel Marine Harmful Algal Bloom: Cyanotoxin (Microcystin) Transfer from Land to Sea Otters. PLoS ONE 5(9):e12576.

Conrad, P. A., E. VanWormer, K. Shapiro, M. Miller, C. Kreuder-Johnson, **T. Tinker**, M. Grigg, J. Largier, T. Carpenter, and J. K. Mazet. 2009. Tracking toxoplasma gondii from land to sea. American Journal of Tropical Medicine and Hygiene 81:198-198.

Jessup, D.A., C. Kreuder-Johnson, **J.A. Estes**, D. Carlson-Bremer, W.M. Jarmin, S. Reese, E. Dodd, **M.T. Tinker**, and M.H. Ziccardi. 2010. Persistent organic pollutants in the blood of free ranging sea otters (*Enhydra lutris* sp.) in Alaska and California. Journal of Wildlife Diseases 46(4):1-20.

Newsome, S.D., **G.B. Bentall**, **M.T. Tinker**, O.T. Oftedal, K. Ralls, M.L. Fogel, and **J.A. Estes**. 2010. Variation in δ13C and δ15N diet-vibrissae trophic discrimination factors in a wild population of California sea otters (Enhydra lutris nereis). Ecological Applications 20:744-752.

Miles, A.K., M.A. Ricca, R.G. Anthony, and **J.A. Estes**. 2009. Organochlorine contaminants in fishes from coastal waters west of Amukta Pass, Aleutian Islands, Alaska, USA. Environmental Toxicology and Chemistry 28:1643-1654.

Tinker, M. T., M. Mangel, and **J. A. Estes**. 2009 Learning to be different: acquired skills, social learning, frequency dependence and environmental variation can cause behaviorally-mediated foraging specializations. Evolutionary Ecology Research, 11: 841-869.

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Johnson, C.K., **Tinker, M.T.**, **Estes, J.A.**, Conrad, P.A., **Staedler, M.**, Miller, M.A., Jessup, D.A. and Mazet, J.A.K. 2009. Prey choice and habitat use drive sea otter pathogen exposure in a resource-limited coastal system. Proceedings of the National Academy of Sciences 106(7):2242-2247.

Anthony, R.G., **J.A. Estes**, M. A. Ricca, A. K. Miles, and E. D. Forsman. 2008. Bald eagles and sea otters in the Aleutian archipelago: indirect effects of trophic cascades. Ecology 89:2725-2735

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Tinker, M.T., **Bentall, G.B.**, and **J.A. Estes**. 2008. Food limitation leads to behavioral diversification and dietary specialization in sea otters. Proceedings of the National Academy of Sciences 105(2):560-565.

CV's for

Zachary Howland Randell
[redacted]
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Education

PhD Candidate, Integrative Biology, Oregon State University (started Fall 2015)
Advisor: Dr. Mark Novak
NSF Graduate Research Fellow, awarded 2016

BS Biology - University of California Santa Cruz (2012)
Senior honors thesis: "The effects of light, depth, and age on the distribution and abundance of extracellular polymeric substances found within a California *Macrocystis pyrifera* kelp bed."
UCSC Diving control board undergraduate representative fall 2010 – fall 2012.

Work Experience

Biological Science Technician – Estes/Tinker Lab, UC Santa Cruz and the U.S. Geological Survey, Western Ecological Research Center, Santa Cruz field station (May 2012 – Sept. 2015)

- Lead on a project (at present, managing remotely from Corvallis) developing and field-testing a new type of tag technology for southern sea otters (*Enhydra lutris nereis)* capable of establishing peer-to-peer wireless networked communication between subcutaneously implanted animals.
- Daily execution of the Santa Barbara Channel (SBC) sea otter research project (May 2012 – April 2014). Responsible for capturing, tracking, and monitoring instrumented sea otters. Required boat and ground based radio telemetry interpretation allowing data collection of body condition, reproductive status, and activity budgets.
- Sole resident who lived and maintained a remote field station.
- Participated in sea otter capture operations. Responsible for capturing, handling, transporting, tagging, and the release of wild sea otters for multiple long-term sea otter monitoring projects throughout CA.
- Database management, SCUBA and intertidal sampling, and otter census field support for USGS and UCSC monitoring projects.

Subtidal Technician – Partnership for the Interdisciplinary Study of Coastal Oceans, UC Santa Cruz (June 2010 – Sept. 2011)

- Surveyed subtidal invertebrates and algae, and benthic, midwater, and canopy fishes (137 dives).
- Deployed, maintained, and retrieved oceanographic monitoring equipment.
- Assisted with SMURF (Standard Monitoring Unit for the Recruitment of Fishes) skin diving collection, fish identification, and fin clip sampling for genetic sampling.

Resident/volunteer Channel Island Marine Wildlife Institute (June 2012 – March 2014)

- Installed, lived, and maintained a USGS field station – a remote marine mammal rehabilitation facility 35 miles north of Santa Barbara.
- As the sole resident, provided security and maintenance throughout the grounds and facility.
- Animal rehab/husbandry of California sea lions incl. feeding, medication, restraint, basic treatment (injections, lancing, tagging, fluids administration), pen cleaning and animal release.
- Assisted during a US Fish and Wildlife declared "UME" (Unusual Mortality Event), during which 126 animals were treated.

Community Outreach and Education

- Guest lecturer for a Marine Conservation undergraduate class at Pacific University (Jan 2017)
- Trained Santa Barbara Zoo volunteers in field protocols to survey and collect wild sea otter data
- Trained CIMWI volunteers in basic animal husbandry
- Organized sea otter and ocean awareness week outreach events at the Santa Barbara Zoo
- Lectured at local K-12 schools on local factors imperiling sea otter recovery

Publications:

- S. Gravem; S. Bachhuber; H. Fulton-Bennett; Z. Randell; A. Rickborn; J. Sullivan; B. Menge. 2017. Transformative Research Is Not Easily Predicted. Trends in Ecology and Evolutionary Biology, 32(11): 824-834.
- T. Tinker; J. Tomoleoni; N. LaRoche; L. Bowen; Z. Randell. Southern Sea Otter Range Expansion and Habitat Use in the Santa Barbara Channel. 2015. Final Report to Bureau of Ocean and Energy Management

Public Speaking:

- Z. Randell; T. Tinker; M. Kenner. "Influence of habitat variation on 35 years of subtidal community structure at San Nicolas Island" California Island Symposium, 4 Oct 2016
- Z. Randell; T. Tinker; M. Staedler; M. Murray; L. Carswell; D. Jessup; B. McConnell. "OtterNet Update: Prototype Microcontroller Constructed and ready for Implantation" Southern Sea Otter Research Update Meeting (SSORUM), 19 Feb 2016
- Z. Randell; T. Tinker; M. Staedler; M. Murray; L. Carswell; D. Jessup; B. McConnell. "Advancing Tag Technology: A Peer-to-Peer Tracking Network for Wild Sea Otters" Sea Otter Conservation Workshop IX, 28 Mar 2015
- Z. Randell; T. Tinker; M. Staedler; M. Murray; L. Carswell; D. Jessup; B. McConnell. "Game Changer: Solar Powered Peer-to-Peer Tracking Network for Oiled and Rehabilitated Sea Otters" OWCN Research Symposium, 23 Jan 2015

Lab/Software Experience

- Developed new protocol for the standardized removal of Extracellular Polymeric Substances from *M. pyrifera* kelp blades.
- Experienced in R, PC-ORD, ImageJ, Excel, Access

SCUBA certifications and experience

- 314 scientific dives, roughly 75 recreational dives
- 100% O2 rebreather certified for sea otter capture diving operations
- Scientific Certified (100 FSW): UC Santa Cruz 20 Jun 2010, Rescue: UCSC: 3 Oct 2008
- Dry Suit, Rescue, Nitrox, and Open water certified (PADI) Seward, AK: 2005 - 2007

Small boat operator

- 221 separate days operating inflatables, Boston Whalers, Andersons, and Radons (8-25').
- Motorboat Operator Training Certification (MOTC) Spring 2011, UCSC
- Checked out as primary operator: R/V Terrace Pt., Lucy M., Sebastes, Whitecap, Pursuit.
- Primary operator for UCSC and USGS projects in near shore and open-ocean conditions including skin, SCUBA, and rebreather diver deployment and retrieval.
- Boat trailering, maintenance, and repair – electrical, fiberglass, painting, trailer body, etc.

References

[redacted]

Curriculum Vitae

Aug 2018

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University of California, Santa Cruz
Long Marine Laboratory
100 Shaffer Rd., Santa Cruz, CA 95060
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Email: dcasper@ucsc.edu

Education

Medical DVM, University of Illinois, Champaign Urbana, IL 1973, Phi Zeta Honor Society
Bachelor of Veterinary Medicine, University of Illinois, Champaign Urbana, IL 1971, Edmund J. James Scholar

Current Position

Director of Veterinary Services at UCSC
Director of BioMed Vivarium at UCSC
Director LML Marine Mammal Stranding network
Attending Veterinarian, Long Marine Laboratory
Attending Veterinarian Moss Landing Marine Lab
Contract Veterinarian Monterey Bay Aquarium

Professional Affiliations

International Association of Aquatic Animal Medicine
Society for Marine Mammalogy
American Association of Zoos and Aquaria
American Veterinary Medical Association
California Veterinary Medical Association

Professional Experience

2000-present	Sea Otter surgical implantation of transmitters, central California coast
2000-present	Contract Veterinarian Monterey Bay Aquarium
1997-present	Director LML Marine Mammal Stranding network
2000-2003	"Tagging of Pacific Pelagics" project (TOPP), sampling and tagging free-ranging sea lions
1995-99	White shark tagging and tracking program, Año Nuevo Island, CA
1996-99	Leopard shark ecology, Elkhorn Slough Research Reserve, Elkhorn, CA
1993	NMFS Dolphin live capture, Beaufort, NC
1992	White sided dolphin research project, UCSC
1992	NMFS Dolphin live capture, Matagorda Bay, TX
1989-91	Director of Research and Veterinary Services, John G. Shedd Aquarium, Chicago, Ill
1989	Dolphin Biology Research Associates live capture, Sarasota, FL
1989	White sided dolphin research project, UCSC
1988	Dolphin Biology Research Associates live capture, Sarasota, FL

Research and Publications

Coccidioidomycosis and Other Systemic Mycoses of Marine Mammals Stranding Along The Central California, USA Coast: 1998-2012
By: Huckabone, Sara E.; Gulland, Frances M. D.; Johnson, Suzanne M.; et al.
JOURNAL OF WILDLIFE DISEASES Volume: 51 Issue: 2 Pages: 295-308 Published: APR 2015

Recovery rates of bottlenose dolphin (Tursiops truncatus) carcasses estimated from stranding and survival rate data
JAMES V. CARRETTA,1 KERRI DANIL, SUSAN J. CHIVERS et al.
Marine Mammal Science
Volume 32, Issue 1, Article first published online: 4 SEP 2015Biochemical and hormonal changes during acute fasting and re-feeding in bottlenose dolphins (Tursiops truncatus)
By: Ortiz, Rudy M.; Long, Brett; Casper, Dave; et al.
MARINE MAMMAL SCIENCE Volume: 26 Issue: 2 Pages: 409-419 Published: APR 2010

An Unusual Mortality Event of Harbor Porpoises (Phocoena phocoena) Off Central California: Increase in Blunt Trauma Rather Than an Epizootic
By: Wilkin, Sarah M.; Cordaro, Joe; Gulland, Frances M. D.; et al.
AQUATIC MAMMALS Volume: 38 Issue: 3 Pages: 301-310 Published: 2012

Isotopic incorporation rates for shark tissues from a long-term captive feeding study
By: Kim, Sora Lee; del Rio, Carlos Martinez; Casper, Dave; et al.
JOURNAL OF EXPERIMENTAL BIOLOGY Volume: 215 Issue: 14 Pages: 2495-2500 Published: JUL 2012

Carbon and nitrogen discrimination factors for elasmobranch soft tissues based on a long-term controlled feeding study
By: Kim, Sora Lee; Casper, Dave R.; Galvan-Magana, Felipe; et al.
ENVIRONMENTAL BIOLOGY OF FISHES Volume: 95 Issue: 1 Special Issue: SI Pages: 37-52 Published: SEP 2012

Meningoencephalitis Associated With Carnobacterium maltaromaticum-Like Bacteria in Stranded Juvenile Salmon Sharks (Lamna ditropis)
Schaffer, P. A.; Lifland, B.; Van Sommeran, S.; et al.
VETERINARY PATHOLOGY Volume: 50 Issue: 3 Pages: 412-417 Published: MAY 2013

Biochemical and hormonal changes during acute fasting and re-feeding in bottlenose dolphins (Tursiops truncatus)
By: Ortiz, Rudy M.; Long, Brett; Casper, Dave; et al.
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Running, swimming and diving modifies neuroprotecting globins in the mammalian brain
Williams, TM (Williams, Terrie M.)[1] ; Zavanelli, M (Zavanelli, Mary)[2] ; Miller, MA (Miller, Melissa A.)[5,4] ; Goldbeck, RA (Goldbeck, Robert A.)[3] ; Morledge, M (Morledge, Michael)[2] ; Casper, D (Casper, Dave)[1] ; Pabst, DA (Pabst, D. Ann)[6] ; McLellan, W (McLellan, William)[6] ; Cantin, LP (Cantin, Lucas P.)[3] ; Kliger, DS (Kliger, David S.)[3]
PROCEEDINGS OF THE ROYAL SOCIETY B-BIOLOGICAL SCIENCES
Volume: 275 Issue: 1636 Pages: 751-758
Published: APR 7 2008

Seasonal Variability in Otariid Energetics: Implications for the effects of predators on localized prey resources, Terrie M. Williams, M. Rutishauser, B. Long, T. Fink, J. Gafney, H. Mostman-Liwanag, D. Casper , Physiological and Biochemical Zoology, May:80(4)

Absence of neurotoxic effects in leopard sharks, Triakis semifasciata, following domoic acid exposure. Schaffer P, Reeves C, Casper DR, Davis CR. Toxicon. 2006 Jun 1;47(7):747-52. Epub 2006 Mar 29
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CANINE DISTEMPER VACCINATION IS A SAFE AND USEFUL PREVENTIVE PROCEDURE FOR SOUTHERN SEA OTTERS (ENHYDRA LUTRA NEREIS)
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JOURNAL OF ZOO AND WILDLIFE MEDICINE Volume: 40 Issue: 4 Pages: 705-710 Published: DEC 2009

Bottlenose Dolphins as Marine Ecosystem Sentinels: Developing a Health Monitoring System
Randall S. Wells, Howard L. Rhinehart, Larry J. Hansen, Jay C. Sweeney, Forrest I. Townsend, Rae Stone, David Casper, Michael D. Scott, Aleta A. Hohn, and Teri K. Rowles
EcoHealth 1, 246–254, 2004 Special issue of "Ecosystem Health" dedicated to symposium in October 2000 in New York

In Vitro Lymphocyte Responses Of Bottlenose Dolphins (Tursiops Truncatus): Mitogen Induced Proliferation
Garet P. Lahvis, Randall S. Wells, David Casper , and Charles S. Via
Marine Environmental Research 34 (1992) 000-000, Elservier Science Publishing, London, Eng.

Bottlenose Health Assessment: Field Report On Sampling Near Beaufort, North Carolina, During July, 1995
NOAA Technical Memorandum NMFS-SEFSC-382

First Record of A Live-Stranded Pan-Tropical Spotted Dolphin Stenella-Attenuata-graffmani in Central California USA.
Worthy, G; Casper, D; Rhinehart, H; Moser, M.
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WEBSITES

http://www.mmapl.ucsc.edu/
Marine Mammal Pathology Library
The Marine Mammal Anatomy and Pathology Library (MMAPL) is a resource for high quality images, information, and training tools describing normal anatomy and species specific pathologies of marine mammals.
MMAPL was developed for the marine mammal stranding community, the larger marine mammal research community, veterinarians, pathologists, and educators.
17 intuitional partners contributed to this project.
Collaboration was key to the development of this unique resource and continues to be critical as MMAPL continues to grow and evolve.

REPORTS

Blood Profiles Of Free-Ranging Bottlenose Dolphins From The Central West Coast Of Florida: Report submitted to the Southeast Fisheries Center of the National Marine Fisheries Service
H. Rhinehart, R. S. Wells, F.. Townsend, J. C. Sweeney, D. R. Casper

Health Assessment Of A Population Of Bottlenose Dolphins, Tursiops Truncatus, At Matagorda Bay, Texas, Following A Mortality Event: Report submitted to the Southeast Fisheries Center of the National Marine Fisheries Service
J. C. Sweeney, D. R. Casper F.. Townsend, L. R Stone, and Larry Hansen

A Model for Assessing the Relative Health of Dolphin Populations: Report submitted to the Southeast Fisheries Center of the National Marine Fisheries Service
J. C. Sweeney, D. R. Casper, J. S. Reif, F. Townsend, R. S. Wells, and Larry Hansen

An independent investigation of the Gulfarium's animal care programs and facility. Report submitted to the Gulfarium, Fort Walton Beach, Florida.
D. Casper, K. Ramirez

POSTER PRESENTATIONS

Sea Lion Anatomy and Patholgy: An Innovative New Website for Sharing Information between Stranding Network Participants:
David Casper, Melissa Miller, Sentiel (Butch) Rommel PhD, Dave Jessup, Leslie A. Dierauf, Frances Gulland PhD, MRCVS, Marty Haulena, Linda Lowenstine, Katie Colegrove, Tanja S. Zabka, Kathy Burek, Judy St. Leger, Beth Buckles, Jim Harvey PhD

Menigoencephalitis In Juvenile Salmon Sharks Associated With Carnobacterium Sp.:
C.R. Davis, B.D. Lifland, P.A. Schaffer, D.R. Casper, and S. Van Sommeran.

Monitoring Heat Flow In Dolphins: A New Method For Assessing Optimal Water Temperature
Casper. D., Rhinehart, H., Costa, D.

Initial Care And Stabilization Of A Stranded Pygmy Sperm Whale, Kogia Breviceps: A Team Approach
Rhinehart, H., Casper, D., Worthy, G.A.J., and Wells, M.

Adaptation of Human Immune Assays to Characterize Lymphocyte Function of the Bottlenose Dolphin
Garet P. Lahvis, Randall S. Wells, David Casper, Charles S. Via

Dr. M. Tim Tinker, Research Biologist
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Academic Record

University of California, Santa Cruz, CA
PhD Ecology and Evolutionary Biology, 1998-2004
Dissertation Research: Population biology and foraging behavior of the southern sea otter
University of Waterloo, Ontario, Canada
M.Sc., Biology, 1991-1993
Thesis: Behavioral ecology and energetics of grey seals (*Halichoerus grypus*) on land-fast ice
University of Guelph, Ontario, Canada
Honors B.Sc., Zoology, 1986-1990
Specialization: Wildlife Biology

Professional Appointments

- Adjunct Faculty, Department of Biology, Dalhousie University, Halifax NS, 2017- present
- Adjunct Faculty, Department of Geography, University of Victoria, Victoria BC, 2017- present
- Associate Adjunct Professor, UC Santa Cruz, Ecology and Evolutionary Biology, 2008 - present
- Research Scientist, US Geological Survey, Western Ecological Research Center, 2008 - 2017
- Assistant Research Biologist, UC Santa Cruz, Ecology and Evolutionary Biology, 2007-2008
- Post-doctoral researcher, UC Santa Cruz, Ecology and Evolutionary Biology, 2004-2007

Primary Publications

Chinn, SM, DH Monson, MT Tinker, MM Staedler, DE Crocker. (in press). Lactation and Resource Limitation Affect Stress Responses, Thyroid Hormones, Immune Function and Antioxidant Capacity of Sea Otters (*Enhydra lutris*). Ecology and Evolution.

Burgess, Tristan L., M. Tim Tinker, Melissa A. Miller, James L. Bodkin, Michael J. Murray, Justin A. Saarinen, Linda M. Nichol, Shawn Larson, Patricia A. Conrad, Christine K. Johnson. (in press). Defining the risk landscape in the context of pathogen pollution: *Toxoplasma gondii* in sea otters along the Pacific Rim. Royal Society Open Science

Gagne, Roderick; Tinker, M; Gustafson, Kyle; Ralls, Katherine; Larson, Shawn; Tarjan, L; Miller, Melissa; Ernest, Holly. 2018. Measures of effective population size in sea otters reveal special considerations for wide-ranging species. Evolutionary Applications, Early Ed. https://doi.org/10.1111/eva.12642

Silliman, Brian. R., Brent B. Hughes, Lindsay C. Gaskins, Qiang He, M. Tim Tinker, Andrew Read, James Nifong, John R. Stepp. 2018. Are the ghosts of nature past haunting conservation today? Current Biology 28(9): R532-R537

Nicholson, T. E., Mayer, K. A., Staedler, M. M., Fujii, J. A., Murray, M. J., Johnson, A. B., Tinker, M. T. and Van Houtan, K. S. 2018. Gaps in kelp cover may threaten the recovery of California sea otters. Ecography, doi:10.1111/ecog.03561

Kenner, M.C. and M.T. Tinker 2018. Stability and change in kelp forest habitats at San Nicolas Island. Western Naturalist. 78(4): 1-11

Hessing-Lewis, M., Rechsteiner, E.U., Hughes, B.B., Tinker, M.T., Monteith, Z., Olson, A., Henderson, M.M., Watson, J.C. 2017. Ecosystem features determine seagrass community response to sea otter foraging. Marine Pollution Bulletin. doi: 10.1016/j.marpolbul.2017.09.047.

Estes, J.A., M.T. Tinker and T.M. Williams. 2017. Advances in the physiology, behavior and ecology of sea otters. In "Biology and Conservation of Musteloids", David W Macdonald, Christopher Newman and Lauren A Harrington (eds), Oxford University Press, Oxford, UK, ISBN-13: 9780198759805

Tinker, M.T., J.L. Bodkin, M. Ben-David and J.A. Estes. 2017. "Otters". In Encyclopedia of Marine Mammals, 3rd Edition., Wursig, B., H. Thewissen, and K. Kovacs (eds), Elsevier Inc., NY, ISBN 9780128043813, pg. 664-671 of 1488 pp.

Estes, J.A. and M.T. Tinker. 2017. "Rehabilitating sea otters: feeling good vs. being effective." In Effective Conservation Science: Data Not Dogma. Kareiva, P., Marvier, M. and Silliman, B. (eds). Oxford University Press, UK, ISBN: 9780198808985, 384pp

Tinker, M.T., and Hatfield, B.B., 2017, California sea otter (Enhydra lutris nereis) census results, spring 2017: U.S. Geological Survey Data Series 1067, 9 p., https://doi.org/10.3133/ds1067

Fujii, J.A., Ralls K, Tinker M.T. 2017 Food abundance, prey morphology, and diet specialization influence individual sea otter tool-use. Behavioral Ecology, 28(5): 1206–1216

Ralls K, Rotzel McInerney N, Gagne RB, Ernest HB, Tinker MT, Fujii J, Maldonado J. 2017. Mitogenomes and relatedness do not predict frequency of tool use by sea otters. Biology Letters13 (3), 20160880

Law, C.J., Baliga,V.B., Tinker, M.T. and Mehta, R.S. 2017. Asynchrony in craniomandibular development and growth in *Enhydra lutris nereis* (Carnivora: Mustelidae): are southern sea otters born to bite? Biological Journal of the Linnean Society https://doi.org/10.1093/biolinnean/blw050

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Breed, G. A., E. A. Golson and M. T. Tinker. 2017. Predicting animal home range structure and transitions using a multistate Ornstein-Uhlenbeck biased random walk. Ecology 98(1): 32-47

Novak, M., J.D. Yeakel, A.E. Noble, D.F. Doak, M. Emmerson, J.A. Estes, U. Jacob, M.T. Tinker and J.T. Wootton. 2017. Characterizing species interactions to understand press perturbations: What is the community matrix? Annual Review of Ecology, Evolution and Systematics, 47(1)

Tinker, M.T., and Hatfield, B.B., 2016, California sea otter (Enhydra lutris nereis) census results, spring 2016: U.S. Geological Survey Data Series 1018, 10 p., http://dx.doi.org/10.3133/ds1018.

Schott, K.C., Krusor, C., Tinker, M.T., Moore, J., Conrad, P.A., Shapiro, K., 2016. Concentration and retention of Toxoplasma gondii surrogates from seawater by red abalone (Haliotis rufescens). Journal of Parasitology, 143(13):1703-1712.

Thometz, N.M., Staedler, M.M., Tomoleoni, J.A., Bodkin, J.L., Bentall, G.B., Tinker, M.T., 2016. Trade-offs between energy maximization and parental care in a central place forager, the sea otter. Behavioral Ecology, 27(5): 1552-1566

Tinker, M.T., Staedler, M.M., Tarjan, L.M., Bental, G.B., Tomoleoni, J.A., and LaRoche, N.L., 2016, Geospatial data collected from tagged sea otters in central California, 1998-2012: U.S Geological Survey data release, http://www.dx.doi.org/10.5066/F76H4FH8.

Tarjan, L.M., and M. T. Tinker. 2016. Permissible Home Range Estimation (PHRE) in Restricted Habitats: A New Algorithm and an Evaluation for Sea Otters. PLoS One, http://dx.doi.org/10.1371/journal.pone.0150547

Chinn, S. M., M. A. Miller, M. T. Tinker, M. M. Staedler, F. I. Batac, E. M. Dodd, L. A. Henkel. 2016. The High Cost of Motherhood: End-Lactation Syndrome in Southern Sea Otters. Journal of Wildlife Diseases, 52(2):307-318. doi: 10.7589/2015-06-158

Tinker, M. Tim, and B. B. Hatfield. 2015. Southwest U.S. Southern sea otter annual range-wide census results: U.S. Geological Survey Data Release, http://dx.doi.org/10.5066/F7F47M5C

Tinker, M.T., B. B. Hatfield, M. D. Harris, and J. A. Ames. 2015. Dramatic Increase in Sea Otter Mortality from White Sharks in California. Marine Mammal Science, 32(1): 309–326,

Krusor, C., W. A. Smith, M. T. Tinker, M. Silver, P. A. Conrad, and K. Shapiro. 2015. Concentration and retention of Toxoplasma gondii oocysts by marine snails demonstrate a novel mechanism for transmission of terrestrial zoonotic pathogens in coastal ecosystems. Environmental Microbiology. 17(11):4527-37

Raimondi, P., L.J. Jurgens, and M.T. Tinker. 2015 Evaluating potential conservation conflicts between two listed species: sea otters and black abalone. Ecology 96: 3102-3108

Novak, M. and M.T. Tinker. 2015. Time-scales alter the inferred strength and temporal consistency of intraspecific diet specialization. Oecologia 178:61–74.

Newsome, S.D., M.T. Tinker, V.A. Gill, Z.N. Hoyt, A. Doroff, L. Nichol, and J.L. Bodkin. 2015. The interaction of intraspecific competition and habitat on individual diet specialization: a near range-wide examination of sea otters. Oecologia, 178: 45-59

Smith, E.A.E., S.D. Newsome, J.A. Estes and M.T. Tinker. 2015. The cost of reproduction: differential resource specialization in female and male California sea otters. Oecologia, 178:17-29

Fujii, J. A., K. Ralls, and M. T. Tinker. 2015. Ecological drivers of variation in tool-use frequency across sea otter populations. Behavioral Ecology, 26(2) 519-526

Stewart, N.A., B. Konar and M.T. Tinker 2015. Testing the nutritional limitation and predator avoidance hypotheses for restricted sea otter habitat use in the Aleutian Islands, Alaska. Oecologia, 177(3):645–655

Tinker, M.T. 2015. "Models and Sea Otter Conservation". Chapter 10 *In* S. Larson, G. VanBlaricom and J. Bodkin, editors, "Sea Otter Conservation", Elsevier, Inc., NY

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Kenner, M. C., J. A. Estes, M. T. Tinker, J. L. Bodkin, R. K. Cowen, C. Harrold, B. B. Hatfield, M. Novak, A. Rassweiler, and D. C. Reed. 2013. A multi-decade time series of kelp forest community structure at San Nicolas Island, California. Ecology 94:2654–2654. http://dx.doi.org/10.1890/13-0561R.1

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Tinker M.T., Guimarães P.R., Novak M., Marquitti F.M.D., L. B.J., Staedler M., Bentall G. & A. E.J. 2012. Structure and mechanism of diet specialization: testing models of individual variation in resource use with sea otters. Ecology Letters 15(5) 475-483.

Bowen L., Miles A.K., Murray M., Haulena M., Tuttle J., Van Bonn W., Adams L., Bodkin J.L., Ballachey B., Estes J., Tinker M.T., Keister R. & Stott J.L. 2012. Gene transcription in sea otters (Enhydra lutris); development of a diagnostic tool for sea otter and ecosystem health. Molecular Ecology Resources, 12, 67-74.

Kim SL, Tinker MT, Estes JA, Koch PL (2012) Ontogenetic and Among-Individual Variation in Foraging Strategies of Northeast Pacific White Sharks Based on Stable Isotope Analysis. PLoS ONE 7(9): e45068. doi:10.1371/journal.pone.0045068

Newsome, Seth D., Justin D. Yeakel, Patrick V. Wheatley, M. Tim Tinker. 2012. Tools for quantifying isotopic niche space and dietary variation at the individual and population level. Journal of Mammalogy.93(2), 329-341

Hatfield, B.B., Ames, J.A., Estes, J.A., Tinker, M.T., Johnson, A.B., Staedler, M.M., and Harris, M.D. 2011. Sea otter mortality in fish and shellfish traps: estimating potential impacts and exploring possible solutions. Endangered Species Research, 13(3): 219-229.

Novak M, J.T. Wootton, D.F. Doak, M. Emmerson, J.A. Estes, M.T. Tinker. 2011. Predicting community responses to perturbations in the face of imperfect knowledge and network complexity. Ecology 92:836–846

Harris, Heather S., Stori C. Oates, Michelle M. Staedler, M. Tim Tinker, David A. Jessup, James T. Harvey, and Melissa A. Miller. 2010. Behavior Associated with Forced Copulation of Juvenile Pacific Harbor Seals (*Phoca vitulina richardsi*) by Southern Sea Otters (*Enhydra lutris nereis*). Aquatic Mammals 36(4): 219-229

Miller MA, Kudela RM, Mekebri A, Crane D, Oates SC, M. Tim Tinker, et al. 2010 Evidence for a Novel Marine Harmful Algal Bloom: Cyanotoxin (Microcystin) Transfer from Land to Sea Otters. PLoS ONE 5(9): e12576.

Conrad, P. A., E. VanWormer, K. Shapiro, M. Miller, C. Kreuder-Johnson, T. Tinker, M. Grigg, J. Largier, T. Carpenter, and J. K. Mazet. 2009. TRACKING TOXOPLASMA GONDII FROM LAND TO SEA. American Journal of Tropical Medicine and Hygiene 81:198-198.

Jessup, D.A., C. Kreuder-Johnson, J.A. Estes, D. Carlson-Bremer, W.M. Jarmin, S. Reese, E. Dodd, M.T. Tinker, and M.H. Ziccardi. 2010. Persistent organic pollutants in the blood of free ranging sea otters (*Enhydra lutris* sp.) in Alaska and California. Journal of Wildlife Diseases, 46(4):1-20

Newsome, S.D., G.B. Bentall, M.T. Tinker, O.T. Oftedal, K. Ralls, M.L. Fogel, and J.A. Estes. 2010. Variation in δ13C and δ15N diet-vibrissae trophic discrimination factors in a wild population of California sea otters (Enhydra lutris nereis). Ecological Applications 20(6):1744-1752

Estes, J.A., M.T. Tinker, and J.L. Bodkin. 2010. Using ecological function to develop recovery criteria for depleted species: Sea otters and kelp forests in the Aleutian Archipelago. Conservation Biology 24(3): 852-860

Tinker, M. T., M. Mangel, and J. A. Estes. 2009. Learning to be different: acquired skills, social learning, frequency dependence and environmental variation can cause behaviorally-mediated foraging specializations. Evolutionary Ecology Research, 11: 841-869

Edwards, M. S., and M. T. Tinker. 2009. Monitoring Benthic Algal Communities: A Comparison of Targeted and Coefficient Sampling Methods. Algae 24(2):111-120.

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Johnson, C.K., Tinker, M.T., Estes, J.A., Conrad, P.A., Staedler, M., Miller, M.A., Jessup, D.A. and Mazet, J.A.K. 2009. Prey choice and habitat use drive sea otter pathogen exposure in a resource-limited coastal system. Proceedings of the National Academy of Sciences 106(7): 2242-2247.

Tinker, M. T., D. F. Doak, and J. A. Estes. 2008. Using demography and movement behavior to predict range expansion of the southern sea otter. Ecological Applications 18(7) 1781-1794.

Peckham, S.H., D. Maldonado Diaz, V. Koch, A. Mancini, A. Gaos, M. T. Tinker, W.J. Nichols. 2008. High mortality of loggerhead turtles due to bycatch, human consumption and strandings at Baja California Sur, Mexico, 2003 to 2007. Endangered Species Research 5(2-3).

Tinker, M.T., J.A. Estes and G. Bentall. 2008. Food limitation leads to behavioral diversification and dietary specialization in sea otters. Proceedings of the National Academy of Sciences 105(2) 560-565

Doak, D.F., J.A. Estes, B.S. Halpern, U. Jacob, D.R. Lindberg, J.R. Lovvorn, D.H. Monson, M.T. Tinker, et al. 2008. Understanding and predicting ecological dynamics: are major surprises inevitable? Ecology 89:952-961.

Jessup, D.A., M.A. Miller, C. Kreuder-Johnson, P. Conrad, M.T. Tinker, J.A. Estes and J.A.K. Mazet. 2007. Sea Otters in a Dirty Ocean. Journal of the American Veterinary Medical Association 231(11): 1648-1652

Tinker, M.T., D.P. Costa, J.A. Estes and N. Wieringa. 2007. Individual dietary specialization and dive behaviour in the California sea otter: using archival time-depth data to detect alternative foraging strategies. Deep Sea Research II 54:330-342.

Tinker, M.T., D.F. Doak, J.A. Estes, B.B. Hatfield, M.M. Staedler, and J.L. Bodkin. 2006. Incorporating diverse data and realistic complexity into demographic estimation procedures: a case study using the California sea otter, *Enhydra lutris nereis*. Ecological Applications 16:2293-2312.

Laidre, K.L., J.A. Estes, M.T. Tinker, J. Bodkin, D. Monson and K. Schneider. 2006. Patterns of growth and body condition in sea otters from the Aleutian archipelago before and after the recent population decline. Journal of Animal Ecology 75: 978-989

Estes, J.A., M.T. Tinker, A.M. Doroff and D.M. Burn. 2005. Continuing sea otter population declines in the Aleutian Archipelego. Marine Mammal Science 21:169–172.

Gerber, L.R., M.T. Tinker, J.A. Estes, D.F. Doak and D. Jessup. 2004. Mortality sensitivity in life-stage simulation analysis: A case study of southern sea otters. Ecological Applications, 14:1554–1565.

Estes, J.A., E.M. Danner, D.F. Doak, B. Konar, A.M. Springer, P.D. Steinberg, M.T. Tinker, and T.M. Williams. 2003. Complex trophic interactions in kelp forest ecosystems. Bulletin of Marine Science, 74: 621-638.

Burn, D.M., A.M. Doroff and M.T. Tinker, 2003. Carrying Capacity and pre-decline abundance of sea otters (*Enhydra lutris kenyoni*) in the Aleutian Islands. Northwestern Naturalist 84(3): 145-148

Doroff, A.M., J.A. Estes, M.T. Tinker, D.M. Burn and T.J. Evans. 2003. Sea otter population declines in the Aleutian Archipelago. Journal of Mammalogy, 84(1): 55-64

Estes, J.A., M.L. Riedman, M.M. Staedler M.T. Tinker, B.E. Lyon. 2003. Individual variation in prey selection by sea otters: patterns, causes, and implications. Journal of Animal Ecology, 72(1): 144-155

Estes, J.A., M.T. Tinker, T.M. Williams, D.F. Doak. 1998. Killer whale predation on sea otters links oceanic and nearshore ecosystems. Science, 282: 473-476

Hatfield, B.H., D. Marks, M.T. Tinker, K. Nolan, J. Pierce. 1998. Attacks on sea otters by killer whales. Marine Mammal Science 14(4): 888-894.

Estes, J.A., D.F. Doak, J.R. Bodkin, R.J. Jameson, D. Monson, J. Watt, M.T. Tinker. 1996. Comparative Demography of Sea Otter Populations. Endangered Species Update 13(12): 11-13

Watt, J.P., B.T. Krausse, M.T. Tinker. 1995. Bald Eagles kleptoparasitizing sea otters at Amchitka Island, Alaska. Condor 97(2): 588-590

Tinker, M.T., K.M. Kovacs, M.O. Hammill. 1995. Behavior and energetics of male gray seals (Halichoerus grypus) breeding on landfast ice. Behavioral Ecology & Sociobiology 36:159-170

Professional Activities

Research Positions:

- 2017-present: Research Ecologist, Nhydra Ecological, Halifax, Nova Scotia
- 2008- 2017: Principal Investigator, USGS Santa Cruz Field Station of the Western Ecological Research Center. Lead scientist in studies of sea otter population biology and near-shore ecology
- 2000-2007: Co-Principle Investigator for long-term, telemetry-based study of sea otter demography and foraging ecology in California. Supervisor: Dr. James Estes

Teaching Positions

Courses Taught:

- Quantitative Ecology (BioE 148): Upper level undergraduate/graduate course on quantitative methods of analysis and modeling in ecology. UC Santa Cruz, CA, Spring 2010, 2012, *2014, 2015*
- Readings in Ecology (BioE 293): Core Graduate Course in Ecology and Evolutionary Biology, UC Santa Cruz, CA, 2008
- Regular Guest Lectures for UCSC courses: Kelp forest Ecology, Ecology of Marine Mammals, Disease Ecology, Conservation Biology, Field Methods in Biology, Community Ecology

Graduate Students Advised

- Sarah Espinosa M.Sc. student, UCSC
- Sarah McKay-Strobel, Ph.D. student, UCSC

- Kat Dale, Ph.D. student, UCSC
- Lily Tarjan, Ph.D. graduate, UCSC
- Ben Weitzman, M.Sc. graduate, UCSC
- Jessica Fujii, M.Sc. graduate, UCSC
- Holly MacCormick, M.Sc. graduate, UCSC
- Michelle Staedler, M.Sc. graduate, UCSC
- Lillian Carswell, M.Sc. graduate, UCSC
- Gena Bentall, M.Sc. graduate, UCSC

Graduate Student Committee Memberships

- Rodrigo Beas, Ph.D. student, UCSC
- Robin Dunkin, Ph.D. student, UCSC
- Jason Hassrick, Ph.D. student, UCSC
- Kristen McCully, M.Sc. student, UCSC
- Kim Brewitt, Ph.D. student, UCSC
- Nicole Thometz, Ph.D. student, UCSC
- Justine Smith, PhD student, UCSC
- Joseph Stewart, PhD student, UCSC
- Mary Young, Ph.D. student, UCSC
- Chris Law, PhD student, UCSC
- Joshua Smith, PhD student, UCSC
- Zach Hoyt, Ph.D. student, UA-Juneau
- Nathan Stewart, Ph.D. student, UAF
- Jackie Lindsey, Masters Student, MLML
- Emily Golson, Masters Student, MLML
- Tristan Burgess, PhD Student, UC Davis
- Erin Rechsteiner, PhD student, U Victoria
- Wendel Raymond, Ph.D. student, UA-Juneau
- Ben Weitzman, PhD student, UAF
- Jessica Hale, PhD student, U. Washington
- Megan Moriarty, PhD Student, UC Davis
- Tracy Grimes, M.Sc. student, San Diego State University
- Zach Randell, Ph.D. student, OSU
- Taylor Gorham, Dalhousie university

Post Doctoral Students Advised or Co-Advised

- Dr. Mark Novak, UCSC, 2011-13
- Dr. Brent Hughes, UCSC, 2014-16

Workgroup and Committee Memberships:

- Invited panelist for international symposium and review of tool-use in non-human animals, convened by University of Oxford, UK, August, 2015
- Invited expert reviewer and participant in Marine Mammal Research Program Review by Canadian Department of Fisheries and Oceans, Ottawa, Ontario, Canada, October 2014
- Invited expert panelist on Alaska Sea Grant and University of Alaska Fairbanks sponsored outreach forum to Alaskan communities to discuss sea otter – human interactions. Juneau, Alaska, May, 2014
- Invited expert panelist and participant in Canadian workshop to review ecological and social impacts of sea otter recovery, sponsored by Pew Fellowships. British Columbia, Canada, June 2014.
- Invited expert panelist for US Fish and Wildlife Service and University of Alaska Fairbanks Symposium on southeast Alaska sea otter recovery, Juneau, Alaska, February, 2013
- Invited expert witness for the black abalone recovery team (NMFS), August 2013
- Invited expert witness for hearings convened by the Federal Marine Mammal Commission (June 2013)
- Member of Southwest Alaska Sea Otter Recovery Team (SWAKSORT) convened by US FWS
- Invited participant, Marine Mammal Commission symposium to advise on the use of population viability analysis in marine mammal populations. Savannah, GA, Sept 2005 (report requested by US Congress)
- Invited participant, Marine Mammal Commission symposium to determine the ecological role of killer whales in the north Pacific. Seattle, WA, Apr. 2005 (report requested by US Congress)
- Invited participant, US Fish and Wildlife Service workshop to develop long-term monitoring plan for sea otters in south-west Alaska. Anchorage, AK, Feb. 2005.
- Invited participant, Alaska Sea Life Center/US Fish and Wildlife Service symposium to determine research priorities for the sea otter in south-west Alaska. Seward, AK, Apr. 2004.
- Invited participant, US Fish and Wildlife Service workshop to study sea otter decline in south-west Alaska. Anchorage, AK, Apr. 2002.
- Invited participant, National Center for Ecological Analysis and Synthesis working group on Ecosystem Based Management: Investigating the Roles of Top Predators, 2004-2007

Professional Society Memberships:

- Member of The Society for Marine Mammalogy, 1991-present
- Member of the Ecological Society of America, 2005-present

Journal Reviews and Editing

- Subject Editor, Ecological Applications (Nov 2013)
- Manuscript Reviews provided regularly (5-15 per year) for the following journals:
    - The American Naturalist
    - Ecology
    - Ecological Applications
    - Marine Mammal Science
    - Proceedings of the Royal Society
    - Journal of Animal Ecology
    - Can. J. Fisheries and Aquatic Science
    - Journal of Wildlife Management
    - Trends in Ecology and Evolution
    - Marine Biology
    - Oecologia
    - Animal Behavior
    - Population Ecology
    - Oikos
    - Marine Ecology Progress Series
    - Behavioral Ecology
    - Journal of Sea Research
    - Ecograophy
    - PLOS One
    - Proceedings of the National Academy of Science (PNAS)

Special Certifications and continued Professional Training:

- Completed Bayesian Statistics workshop, USGS-WERC, 2010: Bayesian inference for environmental scientists, ecologists and wildlife biologists
- Certified DOI Motorboat Operator (MOCC)
- First Aid/CPR certified (current) and trained in Wilderness First Aid

Grants, Awards and Scholarships

- National Science Foundation, 'Kelp forest community resilience in action' (co-PI, 2015-2018)
- Aleutian Bering Sea Islands LCC, 'Assessing effects of climate change and ocean acidification on sea urchin productivity and trophic interactions in the Aleutian Islands: Consequences for sea otter recovery' (PI, 2015-2016)
- US Navy, 'Sub-tidal Community Monitoring, San Nicolas Island' (PI, 2014-2015)
- US Fish and Wildlife Service, 'Aleutian Sea Otter Hot Spot Analysis' (PI, 2014-2014)
- California Coastal Conservancy, 'Sea Otter Habitat Use and Biology in Elkhorn Slough' (PI, 2013-2016)
- Oiled Wildlife Care Network, 'Developing a Network-based Tag for Sea Otter Monitoring' (PI, 2013-2016)
- US Fish and Wildlife Service, 'Sea Otter Ecology in Elkhorn Slough' (PI, 2013-2015)
- US Fish and Wildlife Service, 'Sea Otter Movements and Habitat Use' (PI, 2013-2014)
- US Fish and Wildlife Service, 'Sea Otter Population Analysis, SE Alaska' (PI, 2013-2014)
- Pacific Gas and Electric, 'Effects on Sea Otters of Seismic Surveys and Other Stressors' (PI, 2012-2014)
- US Fish and Wildlife Service, 'Modeling Sea Otter Range Expansion' (PI, 2012-2013)
- California Coastal Conservancy, 'Effect of Sea Otter Stressors, Big Sur and Monterey comparison ' (PI, 2011-2013)
- Department of Interior, 'Coastal Ecosystem Responses to Stressors from Land and Sea' (co-PI, 2010-2015)
- Bureau of Ocean Energy Management , 'Sea Otter Range Expansion in Southern California' (PI, 2010-2014)
- UC Davis/NSF, 'transmission dynamics of Toxoplasma gondii at the land-sea Interface ' (co-PI, 2010-2013)
- Alaska Sea Life Center, 'Report on Commander Island sea otter survey' (PI, 2010-2010)
- US Fish and Wildlife Service, 'Sea Otter Population Viability Analysis' (PI, 2009-2010)
- US Fish and Wildlife Service, 'Stressors Affecting Sea Otter Populations' (PI, 2008-2010)
- NPRB, 'NPRB Project 717, Causes of sea otter decline in SW Alaska' (co-PI, 2007-2010)
- UCSB MMS Coastal Marine Institute, 'Population Biology of Sea Otters at the South of their Range' (co-PI, 2000-2003)

- Research Grant from Friends of the Sea Otter: Development of a Spatially Explicit Population Model for the Southern Sea Otter, 2000
- Departmental Graduate Fellowship, Ecology and Evolutionary Biology Dept., UC Santa Cruz, 1998

Professional Technical Reports:

Tinker, M. T. et al., 2018. Sea otter monitoring plan for Gwaii Haanas National Park Reserve, National Marine Conservation Area Reserve and Haida Heritage Site. Final report for Parks Canada.

Tinker, M. T. et al., 2015. "Sea Otter Range Expansion and Habitat Use in the Santa Barbara Channel." Draft Final Report to the Bureau of Ocean Energy Management. US Geological Survey Project Report, 88 pages

Tinker, M. T., et al., 2013. "Sea Otter Population Biology at Big Sur and Monterey California: Investigating the Consequences of Resource Abundance and Anthropogenic Stressors for Sea Otter Recovery". Final Report to California Coastal Conservancy and U.S. Fish and Wildlife Service. US Geological Survey Project Report. 242 pages

Laird Henkel, Michael D Harris, Jack Ames, R Glenn Ford, Michelle Staedler, M Tim Tinker. 2014. Use of Decoys to Assess Effectiveness of Aerial Surveys for Sea Otters. California Department of Fish and Wildlife Office of Spill Prevention and Response Technical Report 14-2

Miller, M.A., Oates, S.C., Dodd, E,, Johnson, C.K., Tinker, M.T. 2014. Risk Factors for Shark Bite Mortality in Southern Sea Otters. Final Report for California Coastal Conservancy Agreement No. 20129034

Tinker, M.T. 2013. Appendix B: Southwest Alaska Distinct Population Segment of the Northern sea otter (Enhydra lutris kenyoni) Population Viability Analysis (PVA) Update. In USFWS (2013). Southwest Alaska Distinct Population Segment of the Northern Sea Otter (Enhydra lutris kenyoni), Recovery Plan 5-Year Review. Marine Mammals Management Office, US Fish and Wildlife Service.

Estes, J.A., J.L. Bodkin and M.T. Tinker. 2010. "Threatened southwest Alaska sea otter stock: delineating the causes and constraints to recovery of a keystone predator in the North Pacific Ocean". NPRB Project 717 Final Report

Tinker, M. T., J. L. Bodkin, J. A. Estes, K. Ralls. 2009. Appendix B: Population Viability Analysis for the southwest Alaska sea otter. In USFWS (2009). Southwest Alaska Distinct Population Segment of the Northern Sea Otter (Enhydra lutris kenyoni), Draft Recovery Plan. Marine Mammals Management Office, US Fish and Wildlife Service.

Oftedal, O., K. Ralls, M.T. Tinker and A. Green. 2007. Nutritional constraints on the southern sea otter in the Monterey Bay National Marine Sanctuary, and a comparison to sea otter populations at San Nicolas Island, California and Glacier Bay, Alaska. Final Report to the Monterey Bay National Marine Sanctuary and the Marine Mammal Commission.

Tinker, M. T., J. A. Estes, K. Ralls, T. M. Williams, D. Jessup, and D. P. Costa. 2006. Population Dynamics and Biology of the California Sea Otter (Enhydra lutris nereis) at the Southern End of its Range. MMS OCS Study DRAFT REPORT. Page 351. MMS Cooperative Agreement Number 14-35-0001-31063. Coastal Research Center, Marine Science Institute, University of California, Santa Barbara, California.

GB Bentall, MT Tinker. 2006. The effect of the Moss Landing Power Plant thermal discharge plume on sea otter behavior and distribution. Report submitted to the Monterey Bay National Marine Sanctuary Integrated Monitoring Network (SIMoN) and Monterey Bay Sanctuary Foundation

Tinker, M.T., Estes, J.A., Doak, D.F. 2000. Development of a spatially explicit population model to assess potential population impacts associated with translocation of sea otters from south of Pt. Conception. Final report to Friends of the Sea Otter, October, 2000. Monterey, California.

Estes, J.A., Konar, B., Tinker, M.T. 1998. Sea Otter Population Biology and Subtidal Community Ecology at Shemya Island, Alaska. Final Report for Department of Defense Legacy Project Number 9401280 & 9510014

Tinker, M.T., Estes, J.A. 1997. Summary Report on Sea Otter Captures for Blood Contaminant Analysis and Collection of Population Data in the Western Aleutian Islands, 1997. Summary Report to the Navy, U.C. Santa Cruz, CA.

Tinker, M.T., Heaven, P.C., Ingham, L. 1997. Columbia Basin, Large Mammal Monitoring: 1994-97 Aerial Surveys, Final Report. Columbia Basin Fish and Wildlife Compensation Program, Technical Report

Tinker, M.T., Estes, J.A. 1996. The population ecology of sea otters at Adak Island, Alaska. Final Report to the Navy, Contract # N68711-94-LT-4026, U.C. Santa Cruz, CA.

Selected Talks and Presentations at Professional Meetings

Tinker. M. T. "Confessions of a Keystone Carnivore: complexity in food web interactions". Invited Seminar Speaker, Dalhousie University, Oct 2017 [Invited]

Tinker, M.T. "An Old Dog learns New Tricks from a Big Weasel: 25 Years of Sea Otter Research" Invited Keynote Speaker, Sea otter awareness week 2017, Seymour Center, Santa Cruz. Sept 2017.

Tinker. M. T. "Tool Use in Sea Otters" Presentation and Panel Participant, American Archaeology Society Annual International Conference, Vancouver, British Columbia, March 2017 [Invited panelist]

Tinker. M. T. "Confessions of a Keystone Carnivore: when simple trophic cascades go sideways ". Invited Seminar Speaker, Scripps Institute of Technology, Nov 2017 [Invited]

Tinker. M. T. "Complex food web interactions and diverse ecosystem effects of sea otters". Invited Seminar Speaker, Haida Fisheries Conference, Haida Gwaii, British Columbia, March 2016. [presentation] [Invited]

Tinker. M. T. "Sea Otter Ecosystem Function in alternative habitats". Invited Seminar Speaker, Moss Landing Marine Labs, California, April 2015. [presentation] [Invited]

Tinker. M. T. "Growth and Equilibrium in Sea Otters Re-visited: a new paradigm for sea otter conservation". Invited Plenary Presentation to Friends of the Sea Otter Special Event, Big Sur, CA, Sept 2015. [presentation] [Invited]

Tinker, MT, L Carswell, B Hughes, J Tomoleoni, B Weitzman, B Hatfield, J Estes, J Bodkin, K Ralls, L Bowen, K Miles, M Kenner, M Staedler, M Murray, A Johnson, B Kelly, S Espinosa, J Fujii, T Nicholson, K Mayer, M Miller, L Henkel, D Jessup, M Harris, J Ames, C Young, F Batac, E Dodd, T Burgess, C Johnson, P Conrad, K Shapiro, F Gulland, N Thometz, N LaRoche, L Tarjan, G Bentall, E Golson, S Newsome. 2015. Between a rock (crab) and a sharp place: the curious conundrum of the southern sea otter, and some unexpected silver linings. 21st Biennial Conference of the Biology of Marine Mammals: Bridging the Past to the Future, San Francisco, CA. 13-18 December 2015. [presentation] [Abstract]

Tinker, MT, B Hatfield, M Harris, J Ames. 2015. Exponential increase in rate of white shark attacks on sea otters in central California: demographic consequences and possible causes. 2015 American Fisheries Society Meeting, Santa Cruz, CA. 9 April 2015 [presentation] [Abstract] [Invited]

Tinker, M.T., Hughes, B. November 2014. Oral Presentation. From kelp forests to pickle weed: sea otter effects on ecosystem dynamics in two distinct coastal habitats. Invited Presented to the staff for Monterey Bay Aquarium's Conservation Science Seminar Series. [presentation] [Invited]

Tinker, M.T., J.A. Estes and J. L. Bodkin. 2013. "Effects of landscape and limited mobility on sea otter population recovery". Society for Marine Mammalogy, 20th Biennial Conference on the Biology of Marine Mammals, Dunedin, New Zealand. [presentation] [Abstract]

Tinker, M.T. and Novak, M. 2013. "Effects of time-averaged sampling on the inferred strength and temporal consistency of intraspecific diet specialization.". Invited speaker at Special Symposium : "Intra-population Niche Variation: From Incidence to Relevance ", 98th Annual Meeting of the Ecological Society of America, Minneapolis, MN, August 2013. [presentation] [Abstract] [Invited]

Tinker, M.T. 2013. "The sea otters of central California: keystone predators and indicators of near-shore ecosystem influences". Invited plenary speaker at "NRS day 2013: a celebration of the UC Nature Reserve System", Bren School of Environment, UC Santa Barbara, Feb 2013. [presentation] [Invited]

Tinker, M.T. 2013. "A paradigm coming of age? The promises, pitfalls and ontology of the Top-down system of thought in ecology". Invited plenary speaker for Presidential Symposium, Western Society of Naturalists Annual Meeting, Oxnard, CA, November 2013. [presentation] [Abstract] [Invited]

Tinker, MT, B Hatfield, M Harris, J Ames. 2013. Exponential increase in rate of white shark attacks on sea otters in central California: demographic consequences and possible causes. Sea Otter Conservation Workshop. March, 2013, Seattle, WA. [presentation] [Abstract]

Tinker, MT, B Hatfield, M Harris, J Ames. 2012. When the Shark Bites: Implications of Increasing White Shark Attacks for Southern Sea Otters. Southern Sea Otter Research Update Meeting. Feb 2013. Santa Cruz, California. [presentation] [Abstract]

Tinker, M.T., J.L. Bodkin, M. Staedler, D.H. Monson, B. Ballachey, K. Kloecker, G. Esslinger, H. Coletti, G. Bentall, J. Estes, O.T. Oftedal, K. Ralls, J. Tomoleoni, N. LaRoche, B. Weitzman, and J. Perry, 2011, Sea otter foraging ecology and energetics across populations. Sea Otter Conservation Workshop VII, March 2011, Seattle, WA. [presentation] [Abstract]

Tinker, M.T., Hatfield, B.B., Harris, M.D. and Ames, J.A.. 2011. "Increasing mortality from white shark attacks drives decline in southern sea otters: estimating demographic impacts using a spatially structured projection model". Society for Marine Mammalogy, 19th Biennial Conference on the Biology of Marine Mammals, Tampa, Florida. [presentation] [Abstract]

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Tinker, M.T., Doak, D.F. 2002. Southern Sea Otter Demography and Population Analyses. Carnivores 2002 From the Mountains to the Sea: A Conference on Carnivore Biology & Conservation, Monterey, CA. [presentation] [Abstract]

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ANNUAL REPORT ON SEA OTTER (Enhydra lutris) RESEARCH CONDUCTED UNDER PERMIT MA672624-18 DURING 2014

31 January 2015

TO:

US Fish & Wildlife Service
Division of Management Authority
Branch of Permits
4401 North Fairfax Dr., Room 212
Arlington, Virginia 22203

US Fish & Wildlife Service
Ventura Field Office
2493 Portola RD., Suite B
Ventura CA 93003

PERMITTEE:

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Long Marine Laboratory, UC Santa Cruz
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SECTION 1: CAPTURE, MARKING, MORTALITY, AND INCIDENTAL HARASSMENT

Capture and Marking Summary All capture and marking of sea otters was done according to methods described in the most recent amended/renewed version for Permit PRT MA672624. There were 29 sea otters captured under this permit in 2014. Of these 29 animals captured in 2014, 21 were females (18 adults, 2 subadults, and 1 pup) and 8 were males (2 aged adults, 5 adults, and 1 pup). Nine of the animals captured in 2014 had been captured in previous years (Table 1).

All but two of the captured sea otters received flipper tags (either for the first time or for the replacement of lost ones) under this permit in 2014. The exceptions were a pup too small to flipper tag and a recaptured animal whose tags were intact and in good condition. Eleven of the captured sea otters underwent surgery in 2014: 6 for a transmitter implant, 4 for TDR explant surgery only, and 1 to receive a new transmitter and to remove the old transmitter and TDR. Of the 20 sea otters captured for the first time in 2014, 19 received a transponder chip (the small pup did not). A pre-molar tooth was extracted from 10 sea otters and blood samples were taken from 28 animals (Table 2). All blood samples collected during captures have undergone initial processing and have been sent to university and/or state laboratories for analysis, or are stored at the California Department of Fish and Game facility at UC Santa Cruz's Long Marine Laboratory for future analysis.

Twenty-eight sea otters were captured using the diver held trap (Wilson trap) and one with a dip net. There were no mortalities of study animals which occurred within 6 months of capture/handling/surgery in 2014 (see section below on mortality of sea otters captured under this permit). Of the 12 sea otters captured this year with a functioning transmitter (implanted this year or in previous years), four were in the Pt. Conception where tracking activies were suspended in September 2014 due to a lack of funding for extending the project. One of these (BRD1284, a mom with a pup) was last located on 24 June 2014. The remaining three were last located on 29 September 2014. All 8 of the animals with functioning transmitters captured in

2014 are located frequently in the Monterey area. Sea otters without functioning transmitters are incidentally located (Table 1).

Two sea otters were captured with their pups in 2014. One mother, BRD1319, was seen without her pup when her pup would have been approximately 15 weeks of age. This pup, BRD1320, was likely not dependent long enough to survive weaning. The other pup (BRD1324) was an estimated 22 weeks of age when last seen with its mom. This pup was old enough to have survived weaning (Table 3).

<u>Mortality of Implanted Sea Otters</u> Eleven sea otters captured under this permit and implanted/explanted with a TDR and/or a radio transmitter were recovered dead in 2013. None of the 11 had undergone surgery in 2014. Stranded Sea Otter Fact Sheets with final or preliminary necropsy findings for those that were necropsied are included as attachments to this report. Cardiomyopathy and shark bite were the most common causes of death identified (Table 4). A brief summary of each case is presented below, in order of date of recovery.

Aged adult female BRD942 was in fresh condition when found with trauma attributed to shark bite. She was in good body condition prior to the attack.

Aged adult female BRD1158 died after stranding alive. She was pregnant and in poor body condition (emaciated). Cardiomyopathy was determined to be the primary cause of stranding.

Adult male BRD1251 was found by a private citizen in a very decomposed condition along a remote and private stretch of coast. When sea otter researchers searched the area all they could find was the otter's radio transmitter. Therefore cause of death is unknown.

Adult female BRD1110 was recovered in fresh condition. She was emaciated and had gastric ulcers but Microcystin intoxication is suspected of being the primary cause of death.

Adult female BRD1301 was recovered in fresh condition after having been observed (by a private citizen) exhibiting seizure-like movements in Elkhorn Slough. She suffered from cardiomyopathy and possible domoic acid intoxication.

The carcass of adult female BRD1306 was in a mummified condition when recovered and no cause of stranding could be determined.

Adult male BRD1299 was in fresh condition when recovered almost 8 months after being captured and instrumented. Stranding was attributed to cardiomyopathy and a large venous thrombus.

BRD1115, an adult female, was recovered floating offshore in Monterey Bay in a moderate state of decomposition. There was no obvious trauma. Cause of death is listed as "unknown, no trauma" but domoic acid and/or microcystin intoxication is considered consistent with other observations.

Adult female BRD1278 was recovered in moderate condition with multiple wounds consistent with shark bite as the cause of death.

Only the radio transmitter of BRD1169 was found and reported by a private citizen. Cause of death could not be determined.

The carcass of BRD1215, an adult male, was mostly mummified skin and bones when recovered. There were multiple holes in the skin that was suggestive of shark bite, but the state of decomposition prevented determination.

<u>Mortality of Non-Implanted Sea Otters</u> Two sea otters that were captured under our permit in previous years that had never undergone surgical procedures were recovered dead in 2013 (Table 5), and are briefly summarized below.

Aged adult female BRD1209 was recovered in an advanced state of decomposition with evidence of trauma and scavenging. Due to decomposition the source of the trauma is unknown.

BRD1121, an aged adult male, likely died about two weeks after being bitten by a shark. This lingering post-bite survival likely contributed to the lower stranding weight (vs. capture weight).

Incidental Harassment. During wild sea otter captures using the diver held trap (Wilson trap), other sea otters that are resting near the captured otters are incidentally harassed. When the Wilson trap hits the surface, sea otters that are not the intended targets but are within approximately 10 – 15 meters, are usually startled, immediately dive and swim away. We do not or cannot determine the exact sea otter raft size at each capture, but our observational database on tagged study animals (based on 55,000 tagged otter re-sightings collected during recent years) indicates that average resting group size in California is 4.3 otters (standard deviation =4.96, data are log-normally distributed). We made 21 capture runs using Wilson traps during which sea otters were captured in 2014, for which the 95% confidence interval for estimated mean group size (assuming 21 groups of random size) is 2.5–6.7. For each capture run we successfully capture 1.2 animals on average, so excluding captured animals our estimated number of otters incidentally harassed during all capture events is 66, with 95% confidence interval 28–115. We also captured 1 sea otter using a dip net in 2014 (see details below). For every otter dip netted, approximately 2 others are chased but escape. In the tangle nets placed across tidal creeks in Elkhorn Slough, 2 additional otters were harassed (swam over or under the net) for every one successfully captured. Therefore, an additional 2 animals (estimated) were incidentally harassed using dip nets.. Thus the total estimated number of sea otters that were incidentally disturbed during our capture efforts in 2014 is 68, with 95% confidence interval 30-117.

Sea otters are also occasionally disturbed during re-sight activities from our small vessel in the Pt. Conception area. This happens when the observers are attempting to get close enough to determine if females have new pups, are still with their pups, or have recently lost pups. We made 25 boat-based resight surveys in the Pt Conception area and 6 boat-based resight surveys in Elkhorn Slough. Accounting for variation in group size (see above) and with an average of 5 approaches to otter groups per survey, of which approximately 50% result in group disturbance, we estimate that we disturbed as many as 338 individual otters, with 95% confidence interval 258–429.

Progress Made in Meeting Objectives

Progress was made on each of the three projects listed in the 2013 annual report (in the Santa Barbara channel – SBC, in San Luis Obispo County – SLO, and in Elkhorn Slough. A brief summary of each is provided below.

The research objectives for the SBC project (initiated in 2012 and located at the very southern end of the range) include 1) identification of important sea otter resting and foraging areas adjacent to manmade structures; 2) delineation of movement patterns along the southern California coast; and 3) assessment of sea otter distribution and behavior in the vicinity of natural oil and gas seep areas (e.g., Coal Oil Point, Santa Barbara County). Monitoring of tagged study animals was conducted regularly until March 1 when a complication to our logistics occurred that reduced our tracking frequency in this area. On this date, the end of the Gaviota Pier was destroyed by large storm waves which made the boat hoist no longer functional. Because of this, the one-way travelling distance by boat to the Pt. Conception area increased from about 22 km – and taking about 35 minutes – to 78 km, taking about 2.5 hours. In addition to requiring much more fuel, this event required us have more favorable marine forecasts before initiating a tracking or capture trip (for safety considerations). Field monitoring for this project ended in September (as per the mutually agreed-upon funding timetables). A total of 913 re-sights of tagged animals from this study group were made during 2014 (Figures 1 & 2). Five adults and one pup were captured between Gaviota State Park and Pt. Conception in 2014. TDR's were recovered from the adults. One adult female from this project (BRD1278, captured in 2013) was recovered dead (Table 4). Continued periodic monitoring of study animals with still-functioning transmitters will continue as-possible with existing funds.

The second field project was initiated in Sept 2012 in south-central California, in the vicinity of San Luis Obispo (SLO). This project was initiated at the request of US Fish and Wildlife Service and with funding by the utility company PG&E, in order to have a sea otter monitoring program in place to detect possible disturbance to sea otters of human disturbance, specifically the high energy seismic testing that had been proposed by PG&E. This study also has a number of other more general objectives relevant to sea otter conservation (see Annual Permit Report for 2013). Intensive monitoring period for this study concluded in April 2014, when the funding for the project reached its end (note that this monitoring period was extended 6 months beyond the initially anticipated end-date with additional fundig from US FWS). Since that time, we have continued less-intensive monitoring of study animals via weekly surveys, in order to assess animal survival and to make potential retrieval of TDRs more likely. By year's end, 36 SLO study animals were being tracked and 2,634 re-sights of tagged individuals had been made during 2014 (Figure 3). This number includes 4 males originally tagged near Pt. Conception for the Santa Barbara Channel study (SBC) that have moved into the SLO study area (Figure 4). Three of the original SLO study animals captured in 2012 died in 2014 (BRD1209, 1215, and 1251, Tables 4 & 5). Sea otter captures were conducted for this project in March in an attempt to retrieve TDRs. Seven animals were captured but the specifically targeted otters evaded capture.

The third field project was initiated in Sept 2013 in Elkhorn Slough, an estuary near Moss Landing in north-central California. The primary goal of this project is to increase the knowledge of estuarine habitat use by sea otters to appropriately inform the conservation and restoration of suitable habitat and water quality conditions at Elkhorn Slough, by 1) describing spatial patterns of habitat use, movement, and behavior and internal body temperature of sea otters in Elkhorn Slough, and 2) investigating sea otter feeding habits, prey availability and contamination in Elkhorn Slough. Intensive monitoring of marked animals in Elkhorn Slough continued through 2014. Nineteen tagged sea otters are monitored daily in Elkhorn Slough. During 2014, 4965 resights were collected (Figure 5), 103 activity budgets were conducted, 512 forage bouts comprised of 12,448 forage dives were collected, and 24 distribution surveys were completed. Three mortalities of Elkhorn Slough study animals occurred in 2014 (BRD1299, 1301, and 1306. Table 4). During 2014, 6 pups were successfully weaned and currently three tagged females have pups. Females with pups reside in the back of the slough and in the smaller tidal creeks that are protected from human disturbance (Figure 6). Preliminary results from the activity budgets data indicate that otters in Elkhorn Slough forage about 34% of the time which suggests that otters in the slough are not resource limited. No sea otter captures within the Slough occurred in

2014 under our permit. We plan on capturing 5 additional animals from within Elkhorn Slough in 2015 to enhance sample size.

Anticipated studies in 2015 include tagging up to 25 sea otters in the Monterey area for collaborative work with UCSC researchers to evaluate sea otter population and diet changes in response to sea star declines. During these captures we may also potentially deploy/test new network-based tags currently in development: these tags will be similar though smaller in size and weight to the VHF transmitters previously deployed as sub-cutaneous tags, and so will be able to be implanted extra-abdominally (a method shown to be less risky and invasive than intra-abdominal tags) – further communication with the permit office will occur prior to field deployment to ensure that all necessary permissions have been obtained. We also plan to work in collaboration with UCSC and UCD researchers to further investigate effects of sea otters in estuaries (Elkhorn Slough). Finally, we are in discussion with the US Navy regarding the potential for initiating a new population study at San Nicolas Island: if successful we will plan to capture and tag approximately 25 individuals from that population for a 3 year population study – as with the Monterey study, we hope to be able to utilize the new network-based tag for this study as well.

There have been no problems or complications encountered during research activities over the past year (other than the loss of the boat launch at Gaviota, mentioned above). A list of the personnel approved to handle sea otters during captures is provided below, followed by a list of additional personnel involved in field monitoring activities (data collection by radio telemetry) that are not permitted to handle otters.

Individuals permitted to handle otters:

M. Tim Tinker
Jack Ames
Nancy Anderson
James Bodkin
Dan Costa
George Esslinger
James Estes
Christine Fiorello
Heather Harris
Mike Harris
Brian Hatfield
David Jessup
Christine Kreuder-Johnson
Michael Kenner
Lesanna Lahner
Melissa Miller
Daniel Monson
Michael Murray
Seth Newsome
Michelle Staedler
Joseph Tomoleoni
Raymund Wack
Benjamin Weitzman
Terrie Williams
Colleen Young

Additional Tracking Personnel not listed on permit:

Nicole LaRoche
Gena Bentall
Teri Nicholson
Sarah Espinosa
Sarah Chinn
Zach Randell
Jessica Fujii

Additional Personnel requested for addition to permit

We would like to add Brent Hughes, a collaborating UCSC researcher conducting eel grass impact studies in Elkhorn Slough, to the list of permittees allowed him to participate in sea otter tracking, monitoring and capture activities. His CV will be sent electronically to the Division of Management Authority, USWS, in the near future. We would also like to request that Zach Randell and Sarah Espinosa be added to the permit to participate in sea otter captures. Their CVs will also be sent electronically to the Division of Management Authority, USWS, in the near future.

Figures and Tables

Figure 1. Santa Barbara Channel (SBC) 2014 sea otter re-sight locations by sex

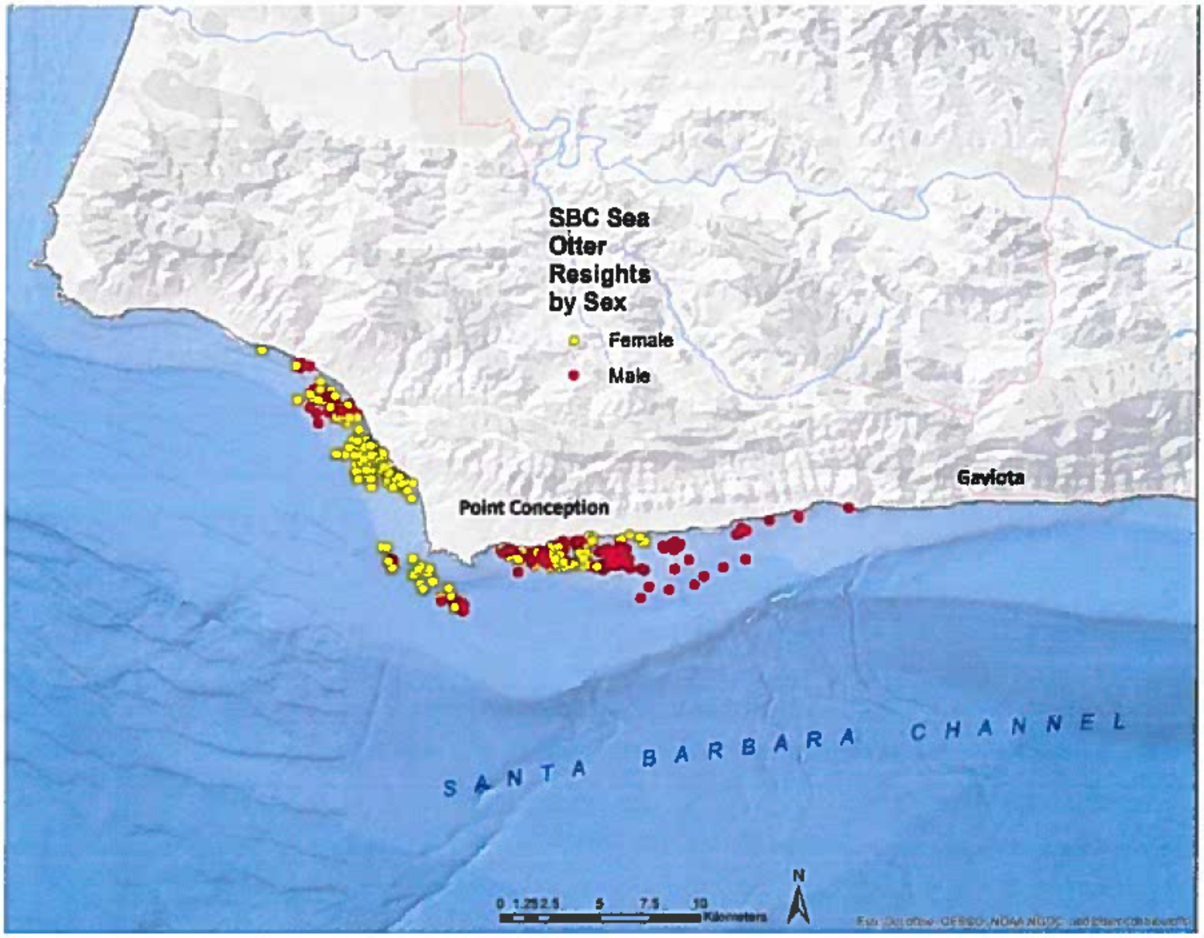

Figure 2. Detail of SBC 2014 sea otter re-sight locations by sex in the Point Conception area.

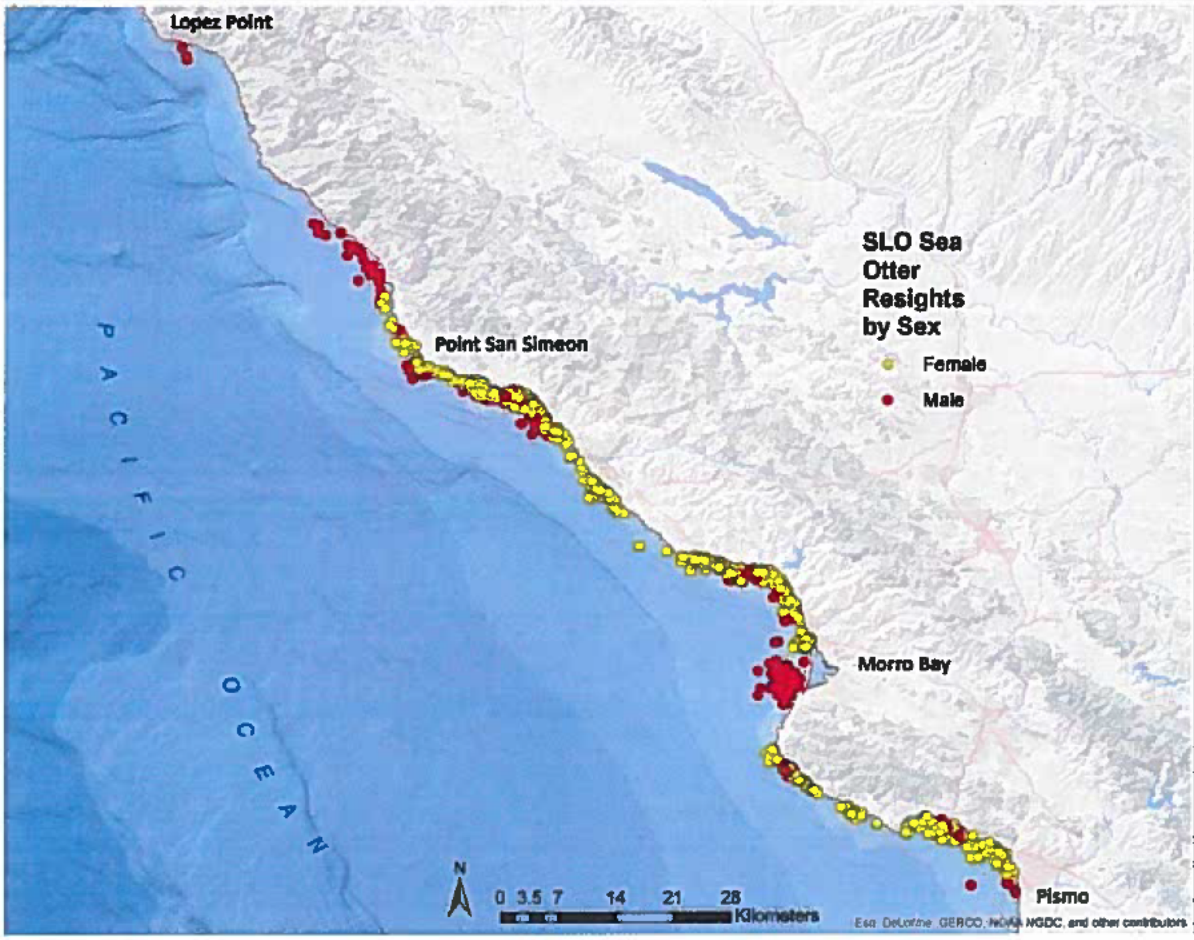

Figure 3. San Luis Obispo (SLO) project 2014 sea otter re-sight locations by sex.

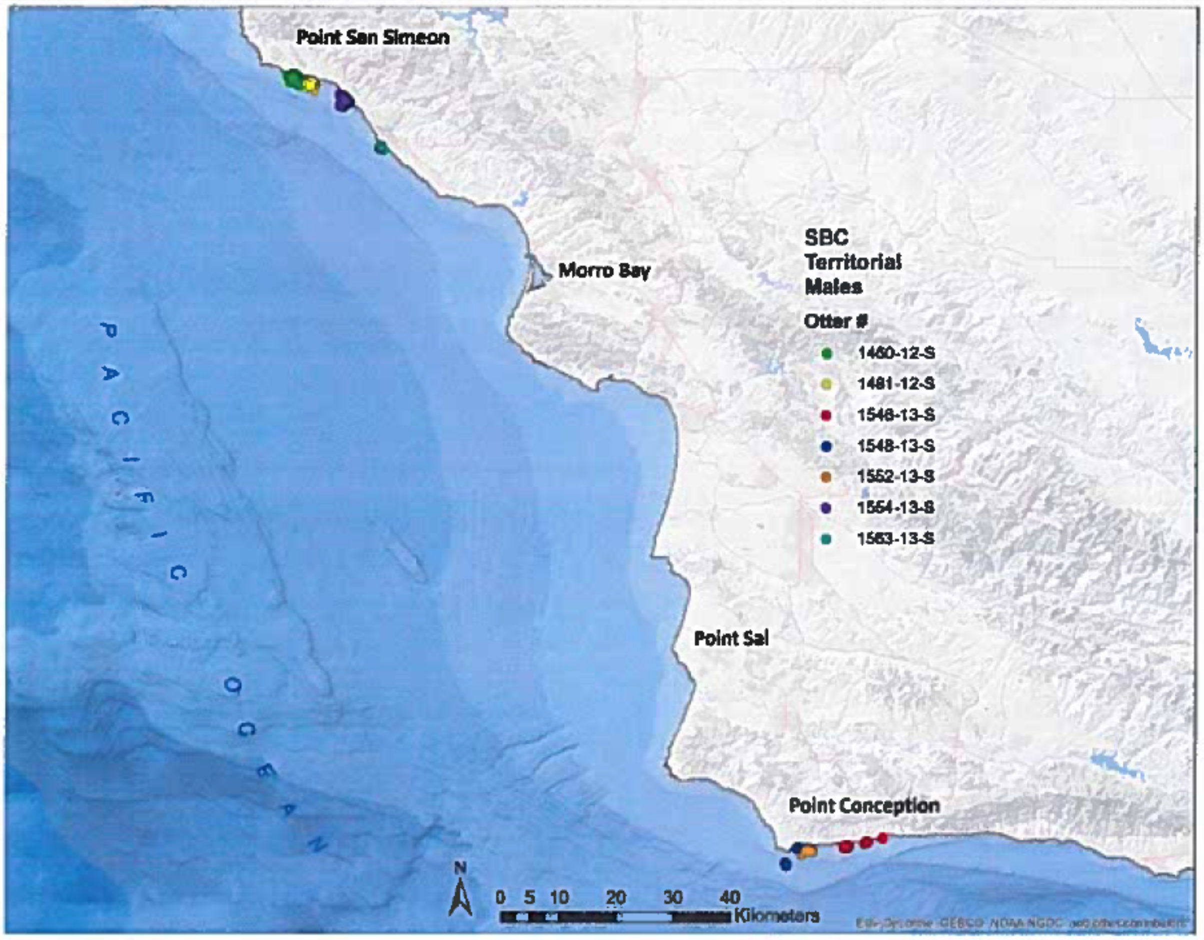

Figure 4. SBC project 2014 sea otter re-sight locations of territorial males. Note presence of several males in territories within the SLO project study area.

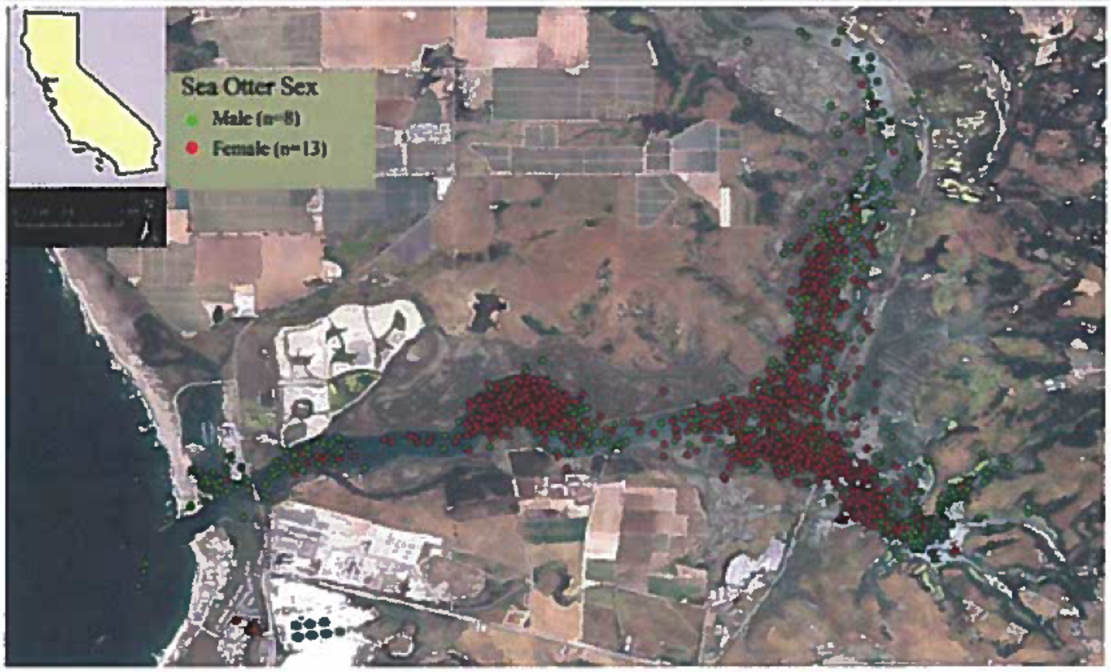

Figure 5. Map of Elkhorn Slough study area showing re-sight locations for male (green) and female (red) tagged sea otters.

Figure 6. Map of Elkhorn Slough study area showing re-sight locations of females with dependent pups.

TABLE I. Summary of sea otters captured in California under Permit MA672624 in 2014

OTTER NO.	CAPTURE DATE	LOCATION	SEX	AGE	WT(LB)	LENGTH(cm)	FUNCTIONING TRANSMITTER?	STATUS (AS OF MID-JAN 2014)
BRD1317-14	10-Mar-14	Pismo Beach	F	SA	38.6	107.9	No	no resight record
BRD1318-14	10-Mar-14	Pismo Beach	F	A	38.6	113.0	No	last seen 6/27/14
BRD1319-14	14-Mar-14	Morro Bay	F	A	48.3	116.9	No	last seen 9/25/14
BRD1320-14	14-Mar-14	Morro Bay	M	P	14.6	85.0	No	last seen with mom 4/14/14
BRD1321-14	14-Mar-14	Morro Bay	F	A	48.5	120.0	No	last seen 9/25/14
BRD1322-14	14-Mar-14	Morro Bay	F	A	49.8	115.6	No	infrequently
BRD1323-14	14-Mar-14	Morro Bay	F	A	48.7	117.1	No	not seen since 10/9/14
BRD1273-13-2	16-Mar-14	Pt. Conception	M	A	75.0	130.1	Yes	last located 9/29/14 *
BRD1270-13-2	19-Mar-14	Pt. Conception	M	A	59.5	124.5	Yes	last located 9/29/14 *
BRD1284-13-2	19-Mar-14	Pt. Conception	F	A	44.1	117.0	Yes	last located 6/24/14 (w/ pup)
BRD1324-14	19-Mar-14	Pt. Conception	F	P	10.1		No	last located 6/24/14 (w/ mom)
BRD1189-12-3	21-Mar-14	Pt. Conception	M	A	62.0	125.0	Yes	last located 9/29/14 *
BRD1122-09-4	1-Jul-14	Monterey	F	A	44.8	117.0	Yes	frequently
BRD1171-11-2	2-Jul-14	Monterey	F	A	50.3	117.0	No	frequently until 11/2014
BRD1325-14	2-Jul-14	Monterey	F	A	59.3	120.9	No	frequently
BRD1326-14	2-Jul-14	Monterey	F	A	38.6	112.5	No	infrequently
BRD1327-14	2-Jul-14	Monterey	F	A	47.2	116.9	No	frequently
BRD1114-09-5	23-Sep-14	Monterey	M	AA	69.0	130.5	Yes	frequently
BRD1205-12-2	23-Sep-14	Monterey	F	A	51.4	122.6	No	infrequently
BRD1328-14	23-Sep-14	Monterey	M	AA	75.2	134.4	Yes	frequently
BRD1329-14	23-Sep-14	Monterey	F	SA	41.5	119.2	Yes	frequently
BRD1330-14	23-Sep-14	Monterey	F	A	40.8	113.7	Yes	frequently
BRD1331-14	23-Sep-14	Monterey	F	A	48.5	121.7	Yes	frequently
BRD1316-13-2	22-Oct-14	Monterey	M	A	78.3	132.5	Yes	frequently
BRD1332-14	22-Oct-14	Monterey	M	A	62.2	124.1	No	frequently
BRD1333-14	22-Oct-14	Monterey	F	A	43.4	121.1	Yes	frequently
BRD1334-14	23-Oct-14	Monterey	F	A	44.3	115.5	No	freqeuently
BRD1335-14	23-Oct-14	Monterey	F	A	48.5	120.8	No	frequently
BRD1336-14	23-Oct-14	Monterey	F	A	47.2	117.2	No	frequently

* when monitoring ceased

TABLE 2. Marks applied to and samples taken from sea otters captured in California under Permit MA672624 in 2014.

							SAMPLES COLLECTED										
														SWABS/SMEARS			
	CAPTURE	R TAG	L TAG	TRANSPONDER	RADIO	TDR			TISSUE	LIVER							
OTTER NO.	DATE	COLOR	COLOR	NUMBER	TRANSMITTER	IMPLANT	TOOTH	BLOOD	PLUG	BIOPSY	HAIR	WHISKER	FAT	BUCCAL	ANNAL	NASAL	SALIVA
BRD1317-14	10-Mar-14	TQ	WH	2013ES007	N	N	N	Y	Y	N	Y	Y	N	Y	Y	Y	N
BRD1318-14	10-Mar-14	PI	WH	SLO-2014-061	N	N	UR	Y	Y	N	Y	Y	N	Y	N	Y	N
BRD1319-14	14-Mar-14	TQ	RE	SLO02014063	N	N	UR	Y	Y	N	Y	Y	N	Y	Y	Y	N
BRD1320-14	14-Mar-14	WH	RE	SLO02014062	N	N	N	Y	Y	N	Y	Y	N	Y	Y	Y	N
BRD1321-14	14-Mar-14	LB	CH	SLO02014064	N	N	UR	Y	Y	N	Y	Y	N	Y	Y	Y	N
BRD1322-14	14-Mar-14	RE	YE	SLO02014065	N	N	UR	Y	Y	N	Y	Y	N	Y	N	Y	N
BRD1323-14	14-Mar-14	LB	WH	SLO02014069	N	N	UR	Y	Y	N	Y	Y	N	Y	Y	Y	N
BRD1273-13-2	16-Mar-14	LB	RE	HAS EXISTING	HAS EXISTING	REMOVED	N	Y	Y	N	Y	Y	Y	N	Y	Y	N
BRD1270-13-2	19-Mar-14	CH	PU	HAS EXISTING	HAS EXISTING	REMOVED	N	Y	Y	N	Y	Y	Y	Y	Y	Y	N
BRD1284-13-2	19-Mar-14	LB	CH	HAS EXISTING	HAS EXISTING	REMOVED	N	Y	Y	N	Y	Y	Y	Y	Y	Y	N
BRD1324-14	19-Mar-14	-	-	N	N	N	N	N	N	N	N	N	N	N	N	N	N
BRD1189-12-3	21-Mar-14	CH	OR	HAS EXISTING	166.193	REMOVED	N	Y	Y	N	Y	Y	Y	Y	Y	Y	N
BRD1122-09-4	1-Jul-14	TQ	TQ	HAS EXISTING	REPLACED	REMOVED	N	Y	N	N	Y	Y	Y	Y	Y	Y	N
BRD1171-11-2	2-Jul-14	WH	RE	HAS EXISTING	N	N	N	Y	Y	N	Y	Y	N	Y	Y	Y	N
BRD1325-14	2-Jul-14	YE	PI	985112001056424	N	N	N	Y	Y	N	Y	Y	N	Y	Y	Y	N
BRD1326-14	2-Jul-14	TQ	LB	985111000128873	N	N	N	Y	Y	N	Y	Y	N	N	Y	Y	N
BRD1327-14	2-Jul-14	TQ	WH	985112001025706	N	N	N	Y	Y	N	Y	Y	N	Y	Y	Y	N
BRD1114-09-5	23-Sep-14	TQ	YE	HAS EXISTING	HAS EXISTING	N	N	Y	Y	N	Y	Y	N	Y	Y	Y	N
BRD1205-12-2	23-Sep-14	YE	OR	HAS EXISTING	N	N	N	Y	N	N	N	Y	N	N	Y	Y	N
BRD1328-14	23-Sep-14	YE	RB	985112001036387	165.068	N	N	Y	Y	N	Y	Y	Y	Y	Y	Y	N
BRD1329-14	23-Sep-14	PI	PI	985111000092584	165.709	N	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	N
BRD1330-14	23-Sep-14	YE	SI	985111000115734	166.022	N	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	N
BRD1331-14	23-Sep-14	RE	YE	985112001033701	166.043	N	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	N
BRD1316-13-2	22-Oct-14	RE	TQ	HAS EXISTING	166.280	N	UR	Y	N	N	Y	Y	Y	Y	Y	Y	N
BRD1332-14	22-Oct-14	RE	YE	985112001060034	N	N	N	Y	Y	N	Y	Y	N	Y	Y	Y	N
BRD1333-14	22-Oct-14	TQ	CH	985112001020950	166.067	N	UR	Y	Y	N	Y	Y	Y	Y	Y	Y	N
BRD1334-14	23-Oct-14	YE	RB	985112001015461	N	N	N	Y	Y	N	Y	Y	N	Y	Y	Y	N
BRD1335-14	23-Oct-14	PU	PU	98511000196596	N	N	N	Y	Y	N	Y	Y	N	Y	Y	Y	N
BRD1336-14	23-Oct-14	TQ	SI	985111000243405	N	N	N	Y	Y	N	Y	Y	N	Y	Y	Y	N

TABLE 3. Summary of Mother/Pup pairs captured in California under Permit MA672624 in 2014.

MOTHER/ PUP	OTTER NO.	SEX	AGE	WT(LB)	LENGTH (cm)	FLIPPER TAGGED	PIT TAGGED?	TRANSMITTER IMPLANTED?	TDR IMPLANTED	CAP/RELEASE DATE	LAST SEEN W/ PUP	FIRST SEEN W/O PUP	PUP SUCCESSFULLY WEANED?
MOM	BRD1319-14	F	A	48 3	116 9	Y	Y	N	N	14-Mar-14	14-Apr-14	21-Apr-14	
PUP	BRD1320-14	M	P	14 6	85 0	Y	Y	N	N	14-Mar-14			unlikely
MOM	BRD1284-13-2	F	A	44.1	117 0	Y	Y	HAS EXISTING	HAS EXISTING	19-Mar-14	24-Jun-14	not seen w/o pup	
PUP	BRD1324-14	F	P	10.1	-	N	N	N	N	19-Mar-14			likely

TABLE 4. Surgically implanted sea otters captured under Permit PRT MA672624 that died in 2014.
Sea otters listed by recovery date.

Otter No.	Age/Sex	Date of Last Surgery	Date Recovered	No. Days Since Last Surgery	Condition	Capture Wt. (lb)	Stranding Wt. (lb)	Primary Cause of Stranding
BRD942	Aged Adult Female	28-Sep-04	20-Feb-14	3,430	Fresh	43.4	43.2	Shark bite
BRD1158	Aged Adult Female	28-Jul-10	22-Feb-14	1,304	Fresh	41.9	44.1	Cardiomyopathy
BRD1251	Adult Male	14-Oct-12	17-Mar-14	519	Advanced	24.7	-	Unknown
BRD1110	Aged Adult Female	27-Oct-10	24-Mar-14	1243	Fresh	41	30.9	Poisoning/Toxins suspected
BRD1301	Adult Female	17-Sep-13	5-Apr-14	200	Fresh	47	52.5	Cardiomyopathy
BRD1306	Adult Female	17-Sep-13	18-May-14	243	Mummified	51.8	-	Unknown
BRD1299	Adult Male	17-Sep-13	10-Jun-14	266	Fresh	75.6	71	Cardiomyopathy
BRD1115	Adult Female	1-Sep-11	29-Jul-14	1,061	Moderate	47.4	52	Unknown
BRD1278	Aged Adult Female	13-Mar-13	31-Jul-14	505	moderate	52.7	45	Shark bite
BRD1169	Adult Female	27-Sep-10	23-Aug-14	1,425	Mummified	28.4	-	Unknown
BRD1215	Adult Male	3-Oct-12	10-Nov-14	768	Mummified	58.7	-	Unknown (probable shark bite)

TABLE 5. Non-implanted sea otters captured under Permit PRT MA672624 that died in 2014.
Sea otters listed by recovery date.

Otter No.	Age/Sex	Date Last Captured	Date Recovered	No. Days Since Last Capture	Condition	Capture Wt. (lb)	Stranding Wt. (lb)	Cause of Stranding
BRD1209	Adult Female	2-Oct-12	26-Jan-14	481	Advanced	49.8	44.1	trauma - unknown source
BRD1121	Adult Male	10-Jun-09	1-Apr-14	1,755	Fresh	71.4	56	Shark bite

ANNUAL REPORT ON SEA OTTER (*Enhydra lutris*) RESEARCH CONDUCTED UNDER PERMIT MA672624-18 DURING 2015

31 January 2016

TO: US Fish & Wildlife Service
Division of Management Authority
Branch of Permits
4401 North Fairfax Dr., Room 212
Arlington, Virginia 22203

US Fish & Wildlife Service
Ventura Field Office
2493 Portola RD., Suite B
Ventura CA 93003

PERMITTEE: Tim Tinker, Research Wildlife Biologist
U.S. Geological Survey – Biological Resources Discipline
Long Marine Laboratory, UC Santa Cruz
100 Shaffer Road
Santa Cruz, California 95060

SECTION 1: CAPTURE, MARKING, MORTALITY, AND INCIDENTAL HARASSMENT

Capture and Marking Summary   All capture and marking of sea otters was done according to methods described in the most recent amended/renewed version for Permit PRT MA672624. There were 15 sea otters captured under this permit in 2015. Of these 15 animals captured in 2015, 14 were females (3 aged adults, 7 adults, 1 subadult, and 3 pups) and only 1 was a male (adult). Four of the animals captured in 2015 had been captured in previous years (Table 1).

All of the captured sea otters received flipper tags (either for the first time or for the replacement of lost ones) under this permit in 2015. Six of the captured sea otters underwent surgery in 2015: 5 for a transmitter implant only and 1 to receive a new transmitter and to remove the old transmitter. All 11 of the sea otters captured for the first time in 2015 received a transponder chip. A pre-molar tooth was extracted from 5 sea otters and blood samples were taken from all 15 animals (Table 2). All blood samples collected during captures have undergone initial processing and have been sent to university and/or state laboratories for analysis, or are stored at the California Department of Fish and Wildlife facility at UC Santa Cruz's Long Marine Laboratory for future analysis.

Eight sea otters were captured using tangle nets in Elkhorn Slough while 7 were caught using the diver held trap (Wilson trap) off the Monterey Peninsula. There were no mortalities of study animals which occurred within 6 months of capture/handling/surgery in 2015 (see section below on mortality of sea otters captured under this permit). All 7 sea otters captured this year with a functioning transmitter were in Elkhorn Slough and all are located frequently. Seven of nine animals without radio transmitters are seen regularly, including one that spent 5 months in Elkhorn Slough but has recently returned to near her capture location off the Monterey Peninsula. The two that have not been seen in some time are weaned pups (Table 1). All three pups that were captured with their mothers in 2015 were successfully weaned (Table 3). Two of these pups were seen after weaning and all three were estimated to have been old enough to survive weaning, including one that was dependent for 11 months (the average dependency period is about 6 months).

Mortality of Implanted Sea Otters Fourteen sea otters captured under this permit and implanted/explanted with a TDR and/or a radio transmitter were recovered dead in 2015. None of the 14 had undergone surgery in 2015, and mortalities appeared to be un-related to capture or surgery activities. Stranded Sea Otter Fact Sheets with final or preliminary necropsy findings for those that were necropsied are included as attachments to this report. Shark bite, cardiomyopathy, and gastrointestinal disease were the most common causes of death identified (Table 4). A brief summary of each case is presented below, in order of date of recovery.

Aged adult male BRD761 was recovered alive in poor condition and euthanized more than 14 years since undergoing surgery. Cardiomyopathy, dental disease and emaciation were significant findings.

Adult female BRD1210 died after stranding alive. Uterine torsion was determined to be the primary cause of stranding.

Adult female BRD1122 stranded moribund 262 days after undergoing surgery. She was suffering from end lactation syndrome (ELS, lactating animal with severe nose wound and emaciated).

Adult male BRD1270 was recovered in fresh condition. He was emaciated (had lost >18lb since his previous capture) and had gastric ulcers and lymphadenopathy.

Adult male BRD1313 was euthanized after stranding in poor condition 581 days after being dip-netted in Elkhorn Slough. Primary cause of death was determined to be cardiomyopathy.

The carcass of aged adult female BRD835 was in an advanced state of decomposition when recovered and no cause of stranding could be determined. It had been over 3,700 days since her surgery.

Just the TDR from this adult female (BRD1255) was recovered and therefore no cause of death could be determined, although trauma – such as shark bite – is suspected.

BRD1126, an aged adult female, was recovered in a moderate state of decomposition. There was no obvious trauma. Cause of death was determined to be a combination of gastrointestinal disease, dental abscess/wear, and ELS.

Aged adult male BRD1156 was recovered in an advanced state of decomposition with multiple wounds consistent with shark bite as the cause of death.

Adult male BRD1230 was in moderate condition when recovered and he also had multiple wounds consistent with shark bite. In addition, scratch marks were observed on bone that match serrations found on white shark teeth.

Adult female BRD1153 stranded alive but died. It had been over 5 years since her previous capture. Enteritis/end lactation syndrome was determined to be the cause of stranding.

The mummified carcass of BRD1216, an adult female, was recovered >1,000 days post-surgery. There was some indication of shark bite, but the state of decomposition prevented determination of cause of death.

The fresh carcass of adult female, BRD1221, was determined to have been bitten by a shark.

Adult female BRD1134 stranded alive but died shortly thereafter. The carcass had multiple stab-like wounds characteristic of shark bite

<u>Mortality of Non-Implanted Sea Otters</u> Three sea otters that were captured under our permit in previous years that had never undergone surgical procedures were recovered dead in 2015 (Table 5), and are briefly summarized below.

Aged adult male BRD987 was recovered in fresh condition over 3,700 days since last being captured. Cause of stranding was shark bite.

BRD1317, a sub-adult male, was recovered fresh with multiple stab-like wounds. A tooth fragment from a white shark was also found.

BRD1332, an adult male, was recovered in an advanced state of decomposition almost a year after being captured and flipper tagged. There was some indication of shark bite, but due to the state of decomposition cause of death could not be determined.

<u>Incidental Harassment</u>. During wild sea otter captures using the diver held trap (Wilson trap), other sea otters that are resting near the captured otters are incidentally harassed. When the Wilson trap hits the surface, sea otters that are not the intended targets but are within approximately 10 – 15 meters, are usually startled, immediately dive and swim away. We do not or cannot determine the exact sea otter raft size at each capture, but our observational database on tagged study animals (based on 55,000 tagged otter re-sightings collected during recent years) indicates that average resting group size in California is 4.3 otters (standard deviation = 4.96, distribution is log-normal). We made 7 capture runs using Wilson traps during which sea otters were captured in 2015, and the 95% confidence interval for mean group size for these 7 captures is 1.6–8.7. For each capture run we successfully captured 1.0 animals on average, so excluding captured animals our estimated number of otters incidentally harassed during all Wilson trap capture events is 23, with 95% confidence interval 4–54. We also captured 9 sea otter using tangle nets placed across tidal creeks in Elkhorn Slough in 2015. Tangle nets are placed across tidal creeks in Elkhorn Slough, and an average of 2 additional otters (±1) were harassed (swam over or under the net) for every one successfully captured. Therefore, an additional 18 animals (95% confidence interval 10–27) were incidentally harassed using tangle nets. Thus the total estimated number of sea otters that were incidentally disturbed during our capture efforts in 2015 is 41 with 95% confidence interval 14–81.

Sea otters are also occasionally disturbed during re-sight activities from our small vessel in Elkhorn Slough. This happens when the observers are attempting to get close enough to determine if females have new pups, are still with their pups, or have recently lost pups. We made 12 boat-based resight surveys in Elkhorn Slough in 2015. Accounting for variation in group size (see above) and with an average of 5 approaches to otter groups per survey, of which approximately 50% result in group disturbance, we estimate that we disturbed as many as 130 individual otters, with 95% confidence interval 83–188.

SECTION 2: PROGRESS MADE IN MEETING OBJECTIVES

Excellent progress was made on both our San Luis Obispo (SLO) and Elkhorn Slough projects in 2015. The SLO project, which was initiated in 2012 at the request of the US Fish and Wildlife Service in order to monitor potential effects of disturbance from PG&E seismic testing, was completed this year. The intensive monitoring period for this study concluded in April 2014, when the funding for the project reached its end (note that this monitoring period was extended 6 months beyond the initially anticipated end-date with additional funding from US FWS). In 2015 tracking efforts continued to wind down throughout the year, but efforts were made to locate the remaining study animals on a weekly basis in order to assess animal survival and to make potential retrieval of TDRs more likely. By the end of the year, tracking efforts had concluded on the SLO project. In addition to monitoring for disturbance from seismic testing, this study also has a number of other more general objectives relevant to sea otter conservation (see Annual Permit Report for 2014). During 2015 a total of 886 resights were collected and entered by field personnel in the San Luis Obispo study area. Six tagged SLO study animals were recovered dead this year. The cause of death and details surround each mortality can be reference earlier in the report (see the Mortality of Implanted Sea Otters section). A total of 4 time-depth recorders were recovered from these stranded animals in the past year.

Our second field project, the Elkhorn Slough Study, was initiated in Sept 2013 in Elkhorn Slough, an estuary near Moss Landing in north-central California. The primary goal of this project is to increase the knowledge of estuarine habitat use by sea otters to appropriately inform the conservation and restoration of suitable habitat and water quality conditions at Elkhorn Slough, by 1) describing spatial patterns of habitat use, movement, and behavior and internal body temperature of sea otters in Elkhorn Slough, and 2) investigating sea otter feeding habits, prey availability and contamination in Elkhorn Slough. Intensive monitoring of marked animals in Elkhorn Slough continued through 2015.

In order to increase our study sample size, particularly since several of the originally tagged study animals died, we conducted one additional day of captures in April 2015. This effort resulted in a total of 8 otters captured (6 adults, 2 pups) using tangle nets set near the entrances of tidal creeks in the Yampah area. The 6 adults (5 females, 1 male), were implanted with radio transmitters and were flipper tagged. The 2 dependent large pups only received flipper tags (no radio transmitters). Of the 25 otters instrumented, 21 (15 females, 6 males) are currently located daily within the slough. One male leaves regularly for extended periods of time but comes back and rests in the raft at Jetty Road. Preliminary data indicate extensive use of inland habitat and small tidal creeks by females, particularly those with small pups, which may be preferred habitats because they are protected from human disturbance (Figure 1). Sea otters in Elkhorn slough appear to have much smaller home ranges (most otters do not move outside the slough) than otters that reside on the outer coast (Figure 1).

Since the beginning of this study a total of 3 sea otters (2 females, 1 male) died during the Spring of 2014, and none have died since. Preliminary results from the necropsies indicated that cardiomyopathy was the primary cause of death for one of the females and the male. The other female disappeared with a 16 week old pup and was located 3 weeks later, too decomposed to determine a cause of death. In total, 13 pups have been born since the start of the study and 9 have been weaned successfully based on an assumed minimum successful weaning age of 21 weeks. Currently, there are four females with dependent pups.

We have been able to meet our forage data goals of 500 “known outcome” dives on untagged otters and 100 “known outcome” dives on tagged individuals per season (fall, winter, spring, and summer). Preliminary results from the 185 activity sessions show that the mean percent time sea otters spend foraging is 37% (Figure 2). In most other areas of central California where sea otters are currently thought to be “resource limited” the mean percent time foraging can be in excess of 40% (Tinker et. al. in review). This suggests that pre-capita food resources in Elkhorn Slough are relatively high and not yet a limiting factor for these sea otters. Clams continue to dominate the diet in these sea otters (>65% of all prey items consumed), with Washington (*Saxidomus nuttall*) and Gaper (*Tresus nutalli*) clams making up 44% and 23% of the total diet, respectively (Figure 3). Most of the forage data are collected from the main channel; however, we are putting more effort into collecting forage data from other habitats including tidal creeks and marsh areas where foraging observations are made more difficult by low water levels and marsh vegetation obscuring the view.

Permit applications have been approved by CDFW, NOAA/MBNMS, and the Moss Landing Harbor District to conduct sub-tidal surveys within the study boundaries of Elkhorn Slough. The sub-tidal surveys aim to use a combination of diver-based visual surveys and excavation of quadrat "pits" (simulating otter foraging behavior) using a suction sampling technique to quantify the abundance, distribution, and size composition of the infaunal invertebrates in Elkhorn Slough. The information obtained from these surveys will be combined with observational foraging data to help paint a more complete picture of the impacts of sea otters on invertebrates in estuarine systems. The results will be compared with similar studies that assessed invertebrate abundance in Elkhorn Slough more than 20 years ago, prior to sea otter occupation within the Slough. We hope to begin sub-tidal surveys starting in the spring of 2016.

In addition to investigating the population structure of sea otter prey items in Elkhorn Slough, we also hope to conduct contaminant analyses on a subset of invertebrates collected form several different locations within the study area. Testing for the presence of toxins or pollutants in sea otter prey can give us an idea of potential contaminant exposures that sea otters might be experiencing while also giving us some insight into the overall health of the invertebrate stocks within the Slough. We have already sent off sea otter tissues that were collected during captures for contaminant analysis and hope to obtain those results soon. Testing for contaminants in both apex predators (sea otters) and their prey can provide us with some clues as to the prevalence and potential transmission or bio-accumulations of toxins in this estuarine system.

Bi-monthly distribution survey data results show a mean of 95 individuals, 8 large pups and 5 small pups in the slough. These surveys provide another means of measuring habitat use patterns of sea otters in the Slough, and how they vary seasonally as a function of tidal height. There is a slight seasonal fluctuation in the total number of sea otters in the slough; the mean number of sea otters in the slough increases in the summer and fall and decreases in the winter and spring (Table 6). Compared to sea otters that live in outer coast, more traditional rocky reef/kelp forest habitats in California (as characterized by the Big Sur-Monterey Study [Tinker et. al., in review]), the sea otters of Elkhorn Slough exhibit better body condition based on initial capture morphometrics, spend less time foraging (indicating relative resource abundance), utilize smaller home ranges (rarely leaving Elkhorn Slough), and demonstrate the use of more distinct areas for foraging and resting. The unique habitats (sea grass beds, mud flats and pickle weed) of Elkhorn Slough provide sea otters with a relatively resource abundant environment in which they can successfully forage, while also providing numerous quiet, protected areas (tidal creeks, pickle weed) where sea otters can rest, haul-out, or perhaps use as nursery areas while avoiding potential disturbance and conserving energy.

Anticipated studies in 2016 include tagging up to 25 sea otters in the Monterey area for collaborative work with UCSC researchers to evaluate sea otter population and diet changes in response to sea star declines. During these captures we may also potentially deploy/test new network-based tags currently in development: these tags will be similar though smaller in size and weight to the VHF transmitters previously deployed as sub-cutaneous tags, and so will be able to be implanted extra-abdominally (a method shown to be less risky and invasive than intra-abdominal tags) – further communication with the permit office will occur prior to field deployment to ensure that all necessary permissions have been obtained (although the implantation of sub-cutaneous transmitter tags is already covered in both Federal permit and under our existing IACUC permit with UC Santa Cruz). We also plan to work in collaboration with UCSC and UCD researchers to further investigate effects of sea otters in estuaries (Elkhorn Slough), and this may include continued population surveys and collection of observational data from already-tagged otters. Finally, we are in discussion with the US Navy regarding the potential for initiating a new population study at San Nicolas Island: if successful we will plan to capture and tag approximately 25 individuals from that population for a 3 year population study – as with the Monterey study, we hope to be able to utilize the new network-based tag for this study as well.

There have been no problems or complications encountered during research activities over the past year. A list of the personnel approved to handle sea otters during captures is provided below, followed by a list of additional personnel involved in field monitoring activities (data collection by radio telemetry) that are not permitted to handle otters.

<u>Individuals permitted to handle otters</u>:

M. Tim Tinker
Jack Ames
Nancy Anderson
James Bodkin
Dan Costa
George Esslinger
James Estes
Christine Fiorello
Heather Harris
Mike Harris
Brian Hatfield
Brent Hughes
David Jessup
Christine Kreuder-Johnson
Michael Kenner
Lesanna Lahner
Melissa Miller
Daniel Monson
Michael Murray
Seth Newsome
Michelle Staedler
Joseph Tomoleoni
Raymund Wack
Benjamin Weitzman
Terrie Williams
Colleen Young

<u>Additional Tracking Personnel not listed on permit</u>:

Gena Bentall
Teri Nicholson
Sarah Espinosa
Zach Randell
Jessica Fujii

<u>Additional Personnel requested for addition to permit</u>

We would like to add Zach Randell, a collaborating UCSC diver & Oregon State University graduate student, to the list of permittees allowing him to participate in sea otter tracking, monitoring and capture diving activities. Zach has worked for our group for several years and has already participated as a tracker (see above list) on the Santa Barbara and SLO projects, but he has recently been trained as an oxygen rebreather sea otter capture diver. Our group of authorized sea otter capture divers is aging, and we identified Zach as an outstanding candidate to join the dive capture team. His CV will be sent electronically to the Division of Management Authority, USFWS, in the near future. We would also like to request that Sarah Espinosa be added to the permit to participate in sea otter captures. Her CV will also be sent electronically to the Division of Management Authority, USFWS, in the near future.

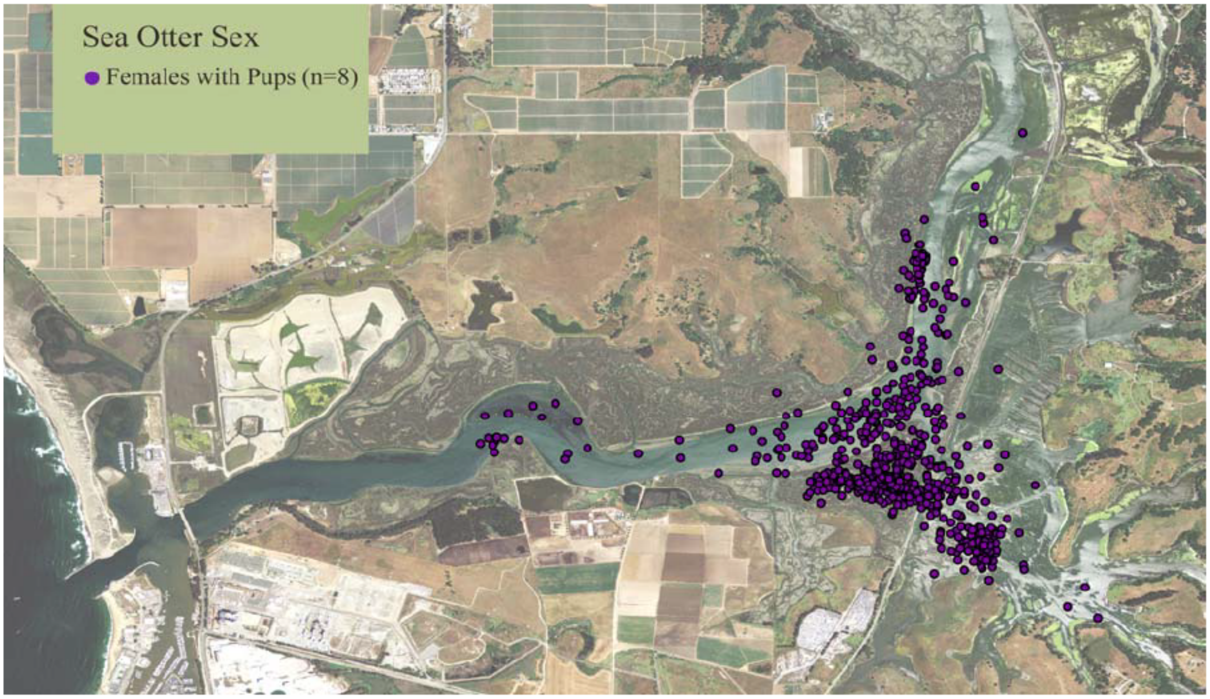

Figure 1. Map of study area and adult female tagged otter re-sights in Elkhorn Slough. Purple circles represent the location of individual Female with pups (n=12).

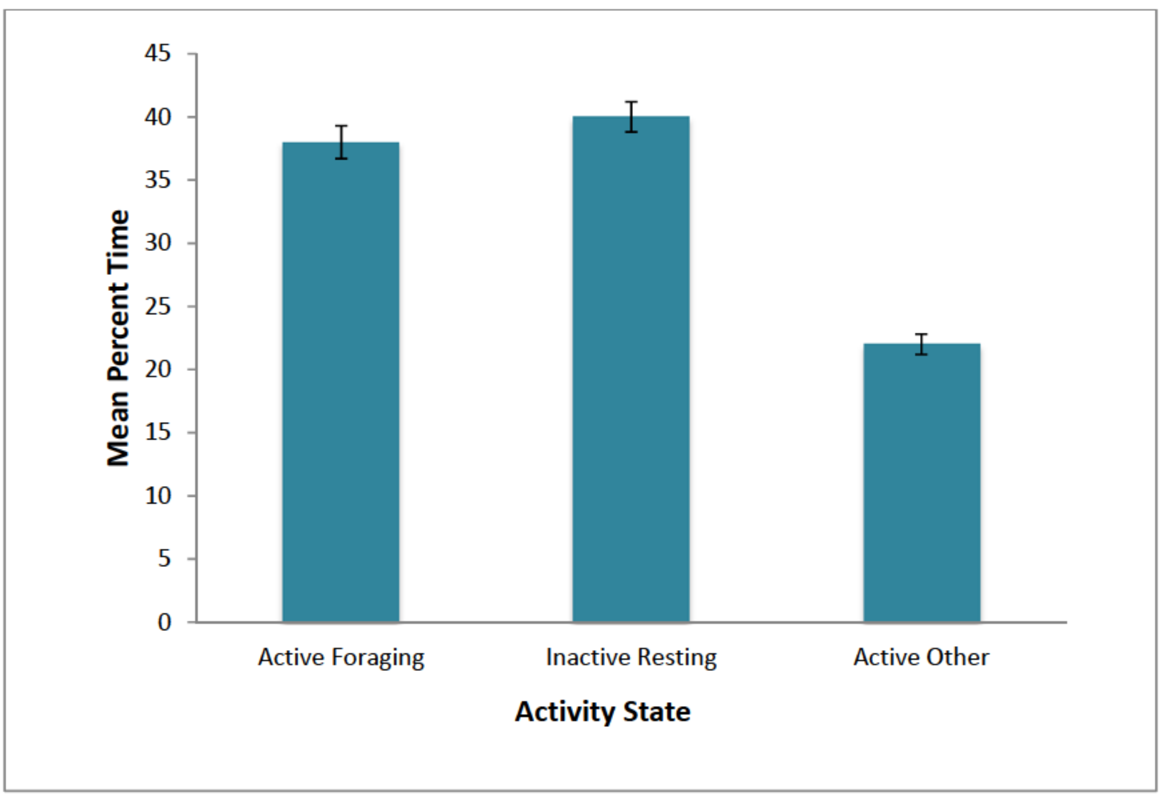

Figure 2. Mean percent time active foraging, inactive resting or active other (grooming, swimming, or interacting) from activity session data from Elkhorn Slough.

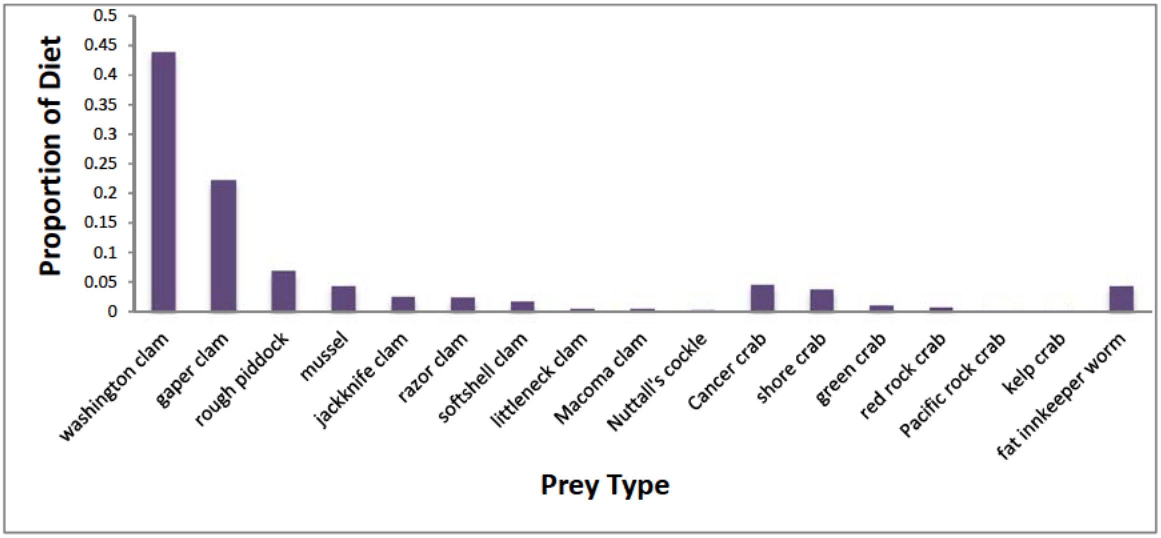

Figure 3. Percent of prey types consumed by sea otters in Elkhorn Slough. Various species of clams represent the highest percent of prey items consumed (>60%) followed by crab species and fat innkeeper worms.

TABLE 1. Summary of sea otters captured in California under Permit MA672624 in 2015.

OTTER NO.	CAPTURE DATE	LOCATION	SEX	AGE	WT(LB)	LENGTH(cm)	FUNCTIONING TRANSMITTER?	STATUS (AS OF MID-JAN 2016)
BRD1337-15	13-Apr-15	ELKHORN SLOUGH	F	A	47.5	117.6	Y	Frequently Resighted
BRD1338-15	13-Apr-15	ELKHORN SLOUGH	F	P	12.4	74.5	N	Irregularly resighted
BRD1339-15	13-Apr-15	ELKHORN SLOUGH	F	A	43.3	120.9	Y	Frequently Resighted
BRD1340-15	13-Apr-15	ELKHORN SLOUGH	F	SA	36.5	109.2	Y	Frequently Resighted
BRD1341-15	13-Apr-15	ELKHORN SLOUGH	F	A	46.9	115.0	Y	Frequently Resighted
BRD1342-15	13-Apr-15	ELKHORN SLOUGH	F	P	18.1	87.9	N	Last seen 30 Nov 2015
BRD1343-15	13-Apr-15	ELKHORN SLOUGH	M	A	59.9	126.6	Y	Frequently Resighted
MBA518-10-2	13-Apr-15	ELKHORN SLOUGH	F	A	42.0	116.6	Y	Frequently Resighted
BRD1344-15	1-Jul-15	MONTEREY	F	A	41.1	114.7	N	Frequently Resighted
BRD1345-15	1-Jul-15	MONTEREY	F	A	41.3	116.5	N	Frequently Resighted
BRD1346-15	1-Jul-15	MONTEREY	F	A	57.7	117.5	N	Frequently Resighted
BRD1111-09-3	2-Jul-15	MONTEREY	F	AA	61.2		N	Frequently Resighted
BRD1125-09-3	2-Jul-15	MONTEREY	F	AA	63.6	122.6	N	Frequently Resighted
BRD1347-15	2-Jul-15	MONTEREY	F	P	21.0	90.0	N	Last seen 15 Aug 2015
BRD999-05-3	2-Jul-15	MONTEREY	F	AA	37.1	117.4	N	Frequently Resighted

TABLE 2. Marks applied to and samples taken from sea otters captured in California under Permit MA672624 in 2015.

							SAMPLES COLLECTED										
	CAPTURE	R TAG	L TAG	TRANSPONDER	RADIO	TDR			TISSUE	LIVER				SWABS/SMEARS			
OTTER NO	DATE	COLOR	COLOR	NUMBER	TRANSMITTER	IMPLANT	TOOTH	BLOOD	PLUG	BIOPSY	HAIR	WHISKER	FAT	BUCCAL	ANNAL	NASAL	SALIVA
BRD1337-15	13-Apr-15	CH	WH	ES2015008	Y	N	Y	Y	Y	N	Y	Y	Y	Y	N	Y	N
BRD1338-15	13-Apr-15	LB	WH	ES2015010	N	N	N	Y	Y	N	N	N	N	N	N	N	N
BRD1339-15	13-Apr-15	CH	CH	ES2015011	Y	N	Y	Y	Y	N	Y	Y	Y	Y		Y	
BRD1340-15	13-Apr-15	WH	RB	ES2015012	Y	N	Y	Y	Y	N	Y	Y	Y		Y	Y	N
BRD1341-15	13-Apr-15	WH	PI	ES2015013	Y	N	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	N
BRD1342-15	13-Apr-15	CH	LG	ES2015014	Y	N	N	Y	Y	N	N	N	N	N	N	N	N
BRD1343-15	13-Apr-15	CH	PI	ES2015015	Y	N	Y	Y	Y	N	Y	Y	Y	Y		Y	N
MBA518-10-2	13-Apr-15	OR	WH	has existing	Y	N	N	Y	Y	N	Y	Y	Y	N	Y	Y	N
BRD1344-15	1-Jul-15	LG	TQ	2015MBA001	N	N	N	Y	Y	N	Y	Y	N	Y	Y	Y	N
BRD1345-15	1-Jul-15	CH	PU	2015MBA002	N	N	N	Y	Y	N	Y	Y	N	Y	Y	Y	N
BRD1346-15	1-Jul-15	TQ	OR	2015MBA003	N	N	N	Y	Y	N	Y	Y	N	Y	Y	Y	N
BRD1111-09-3	2-Jul-15	PI	WH	has existing	N	N	N	Y	Y	N	Y	Y	N	Y	Y	Y	N
BRD1125-09-3	2-Jul-15	TQ	LB	has existing	N	N	N	Y	N	N	Y	Y	N	Y	Y	Y	N
BRD1347-15	2-Jul-15	TQ	TQ	2015MBA004	N	N	N	Y	Y	N	Y	Y	N	Y	N	Y	N
BRD999-05-3	2-Jul-15	PI	TQ	has existing	N	N	N	Y	N	N	Y	Y	N	Y	N	Y	N

TABLE 3. Summary of Mother/Pup pairs captured in California under Permit MA672624 in 2015.

MOTHER/ PUP	OTTER NO.	SEX	AGE	WT(LB)	LENGTH (cm)	FLIPPER TAGGED	PIT TAGGED?	TRANSMITTER IMPLANTED?	TDR IMPLANTED	CAP/RELEASE DATE	LAST SEEN W/ PUP	FIRST SEEN W/O PUP	PUP SUCCESSFULLY WEANED?
MOM	BRD1337-15	F	A	47 5	117 6	Y	Y	Y	N	13-Apr-15	20-Aug-15	29-Aug-15	Yes
PUP	BRD1338-15	F	P	12 4	74 5	Y	Y	N	N	13-Apr-15			Elkhorn
MOM	MBA518-10-2	F	A	42 0	116 6	Y	Y	TX REPLACED	HAS EXISTING	13-Apr-15	29-Nov-15	6-Dec-15	Yes
PUP	BRD1342-15	F	P	18 1	87 9	Y	Y	N	N	13-Apr-15			Elkhorn
MOM	BRD999-05-3	F	A	37 1	117 4	Y	Y	N	N	2-Jul-15	15-Aug-15	30-Aug-15	Yes
PUP	BRD1347-15	F	P	21 0	90 0	Y	Y	N	N	2-Jul-15			Monterey

TABLE 4. Surgically implanted sea otters captured under Permit PRT MA672624 that died in 2015.
Sea otters listed by recovery date.

Otter No.	Age/Sex	Date of Last Surgery	Date Recovered	No. Days Since Last Surgery	Condition	Capture Wt. (lb)	Stranding Wt. (lb)	Primary Cause(s) of Stranding
BRD761	Aged Adult Male	23-Sep-99	1-Jan-15	5,579	fresh	-	45.1	cardiomyopathy, dental disease, emaciation
BRD1210	Adult Female	2-Oct-12	24-Feb-15	875	fresh	40.6	34 3	uterine torsion, blindness, acanthacephalan peritonitis
BRD1122-09-4	Adult Female	1-Jul-14	20-Mar-15	262	fresh	44.8	33.4	end lactation syndrome
BRD1270-13-2	Adult Male	19-Mar-14	1-Apr-15	378	fresh	59.5	41 3	gastric ulcers, lymphadenopathy, pulmonary edema
BRD1313	Adult Male	19-Sep-13	23-Apr-15	581	fresh	75.2	50 2	cardiomyopathy
BRD835-01-7	Aged Adult Female	1-Feb-05	4-May-15	3,744	advanced decomp.	47.3	-	unknown
BRD1255-12	Adult Female	15-Oct-12	31-May-15	958	unknown	35.7	-	unknown
BRD1126-09-3	Aged Adult Female	29-Jul-10	16-Jun-15	1,783	moderate decomp.	47.8	37.6	gastrointestinal, dental abscess/tooth wear, end lactation syndrome
BRD1156-10-2	Aged Adult Male	11-Feb-11	25-Aug-15	1,656	advanced decomp.	79.2	74	shark bite
BRD1230-12	Adult Male	5-Oct-12	21-Sep-15	1,081	moderate decomp.	61.7	-	shark bite
BRD1153-10-2	Adult Female	1-Feb-10	3-Oct-15	2,070	fresh	41	29 2	enteritis/end lactation syndrome
BRD1216-12	Adult Female	3-Oct-12	21-Oct-15	1,113	mummified	46.1	-	unknown
BRD1221-12	Adult Female	4-Oct-12	22-Oct-15	1,113	fresh	42.6	40 2	shark bite
BRD1134-09-4	Adult Female	3-Feb-11	14-Dec-15	1,775	fresh	47.8	50.6	shark bite

TABLE 5. Non-implanted sea otters captured under Permit PRT MA672624 that died in 2015.
Sea otters listed by recovery date.

Otter No.	Age/Sex	Date Last Captured	Date Recovered	No. Days Since Last Capture	Condition	Capture Wt. (lb)	Stranding Wt. (lb)	Primary Cause(s) of Stranding
BRD987-02-2	Aged Adult Male	6-Apr-05	28-May-15	3,704	fresh	39.5	49 9	shark bite
BRD1317-14	Subadult Male	10-Mar-14	17-Oct-15	586	fresh	38.6	47.1	shark bite
BRD1332-14	Adult Male	22-Oct-14	19-Oct-15	362	advanced decomp.	62.2	41 5	unknown

Table 6. Mean number of sea otters (independents, large pups and small pups) per season counted in Elkhorn Slough. Data based on biweekly distribution surveys.

Season	Independents	Large Pups	Small Pups	Totals
Winter 2013	80	9	5	94
Spring 2014	83	7	6	96
Summer 2014	104	8	4	116
Fall 2014	110	4	4	118
Winter 2014	98	6	4	108
Spring 2015	86	6	6	98
Summer 2015	99	13	5	118

BISON CONNECT

Vargas, Darcy <darcy_vargas@fws.gov>

Research Application # 672624

Vargas, Darcy <darcy_vargas@fws.gov> Mon, Apr 1, 2019 at 12:27 PM
To: Joe Tomoleoni <jtomoleo@ucsc.edu>

Dear Joe,

Ref: Application # 672624 to conduct research on Southern Sea otters.

I am reaching out in regards to your referenced application. Although, your application has already been reviewed by this office and has been sent off to internal reviewers within the U.S. Fish and Wildlife Service, your application was found to be too incomplete to forward to our external reviewers at this time. Please understand that we must have answers provided directly to the application questions. Many of the application questions referenced an enclosure package, which is okay. However, the enclosure then, often references other documents and/or question responses for answers to be inferred and/or researched. We do not have the means to do this and it is imperative that the application responses be clear and precise. Therefore, please review the following requests for additional information and clarity. Once this information is received, your application will be sent to our external reviewers. After at that time, we may have additional questions that need to be addressed before we publish this application request in the Federal Register.

1. Provide a numerical response to the application question on Part I, # 7.b (pg. 5).

2. Respond to application question on Part I, # 7.c. (pg. 5).

3. Respond to application question on Part I, # 8, and if applicable, # 8.h. and/or 8.i. (pgs. 5 & 6).

4. Please respond directly to application questions 20.a. of the application instead of referring to responses to other questions asked in the application.

5. Please respond directly to application questions 20.d. of the application. The current application response simply states "Question 10 has been completed."

6. Please respond directly to application questions 20.e. instead of referring to responses that could be found in *Lander et all* (2001). Each application question must have a direct response provided and the response should not reference information found in another location (a different application question, published paper, protocols, and/or enclosures).

7. Please respond directly to application questions 20.f.iii, 20.f.iv, 20.f.v, 20.f.vi. of the application. The responses to these questions simply states "Refer to Table 1, above."

8. Please respond directly to application questions 20.g.i, 20.g.ii, 20g.iii, 20.g.iv, 20.g.v. and 20.g.xiii. of the application. These questions were not responded to.

9. Please respond directly to application questions 20.hi. 20.h.ii, and 20.hiii. of the application. A general paragraph was provided, but none of these question were responded to directly.

10. In regards to question 20.i. of the application, please ensure to have provided all responses that you want reviewed directly in your response. It is noted that your response states to "see Table 1 for more information." However, we need clear and precise responses and therefore, we will not infer your response by reviewing the table.

11. Your table provided in response to question 21 of the application is unclear. Why are the first 2 rows of the tables left black for rows c. through i.? Please provide an updated table that is completed in entirety and that reflects your current and complete application requests.

12. Respond to question 22. of the application in entirety. The application response states "this has already been addressed in Question 10, section h." However, it is unclear as to what you are referring to by Section H of the application and regardless, each application question must be responded to directly.

13. Regarding female-pup calf pairs, your application clearly identifies that research is intended to be conducted on the pairs. Therefore, please clarify how impacts would be minimized. Pups weighing less than 11 pounds won't be flipper tagged. Will anything else be done? The response to question 23 states that "very small pups are generally avoided

when attempting to capture sea otters." Another application response states that pups 1-2 weeks of age won't be targeted, yet your application requests to work on all age classes. Those responses contradict each other. Therefore, please provide updated and consistent application responses regarding research proposed to be done on pups and female-calf pairs. Also, ensure to responds directly to application questions requesting information on what procedures are being requested for each activity via age class and what precautions would be taken.

14. Please respond directly to question 25 of the application and explain how the research will involve the lease possible degree of pain without referencing other documents. The application response states "refer to methods in Question 10 and in this most recent section ,a as well as our IACUIC SOPs, and numerous published peer-review papers provided in this application."

15. Respond to question 29.a. through 29.j. of the application and provide the requested table, in table format.

16. Respond to application question 29.k.vi. of the application in entirely. The application response states "N/A." However, the application response also confirms that samples will be from wild animals. Therefore, a response to the question is required because intrusively collected samples are being proposed to be taken from wild sea otters. This question is applicable for our review purposes.

17. Respond to application question 29.l. in entirety. The application response states "Refer to Table 1, and the additional information provided in (k), above."

18. Please clarify your responses to application questions 20 and 30. The following names were included in the application response to names of personnel who will conduct the sampling. However, these same names were not included in your list of all personnel that will be involved in the project: Cara Field, Shawn Johnson, Clarie Simeone, Dave Casper, Marissa Yound, and Michelle, Staedler.

19. The cover letter enclosed with the application package states that the only amendment being requested is to add 3 personnel to the project. However, the application responses do not support that statement. Therefore, please provided a final confirmation of all personal whom are being requested to be included as co-investigators.

- Question 30 of the application requests to add Zachary Randell as a new co-investigator. However, he was included on USGS's previously issued permit.
- The following personnel were not included as amendments to add as co-investigators and were not included in the application response to question 30. However, these names were included in the list of personnel who will conduct the sampling (pg. 25 of the application enclosure). They were not previously included on USGS's permit. Therefore, they appear to be new amendment requests.

  --Shawn Johnson (DMV)
  --Cara Field (DMV)
  --Claire Simeone (DMV)
  --Marissa Young
  --Michelle Staedler

20. CVs were provided for Zachary Randell, Tim Tinker, and Dave Casper. Thank you. However, you must also provide the CVs for every other PI and co-investigator (including samplers) being requested to be included in this renewal and amendment application. Also, please understand that we will not reference or look for CVs included as part of previously submitted applications.

21. Please provide your 2018 report.

In accordance with 50 CFR 13.ll(e), if the requested information is not received by this office by May 16, 2019 (45 calendar days of the date of this email), your application will be abandoned and administratively closed. Once a file is closed, you will need to submit a new application, and all required fees, for the Service to consider your proposed activity.

Respectfully,

Darcy Vargas
Biologist
US Fish and Wildlife Service
MS: IA
5275 Leesburg Pike
Falls Church, VA 22041-3803
www.fws.gov
www.cites.org

Vargas, Darcy <darcy_vargas@fws.gov>

Research Application # 672624

Joe Tomoleoni <jtomoleo@ucsc.edu> Mon, Apr 1, 2019 at 12:44 PM
To: "Vargas, Darcy" <darcy_vargas@fws.gov>

Hi Darcy,

Thank you for your detailed email regarding our renewal application. I apologize that the application was not as complete as it should have been, and we will get to work on addressing each of these points right away. We will send you the additional information required as soon as possible.

Thank you,

Joe

Joe Tomoleoni
Biologist
U.S. Geological Survey
Western Ecological Research Center
Santa Cruz Field Station
2885 Mission St.
Santa Cruz, CA 95060
831.254.9750
jtomoleo@ucsc.edu

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Vargas, Darcy <darcy_vargas@fws.gov>

Research Application # 672624

Joe Tomoleoni <jtomoleo@ucsc.edu> Tue, Apr 16, 2019 at 2:30 PM
To: "Vargas, Darcy" <darcy_vargas@fws.gov>
Cc: Brian Hatfield <brian_hatfield@usgs.gov>, "Yee, Julie" <julie_yee@usgs.gov>

Hello Darcy,

In addition to the two previous questions, we have one more additional question regarding the table in #21. Does column C (Level A or Level B Harassment) include or exclude the values entered for column H (Max. # non- target conspecifics incidentally harassed). We are having difficulty determining the difference between Column H and Level B Harassment.

Thank you,

Joe

Joe Tomoleoni
Biologist
U.S. Geological Survey
Western Ecological Research Center
Santa Cruz Field Station
2885 Mission St.
Santa Cruz, CA 95060
831.254.9750
jtomoleo@ucsc.edu

On Thu, Apr 11, 2019 at 3:01 PM Joe Tomoleoni <jtomoleo@ucsc.edu> wrote:

> Hello Darcy,
>
> We are working on addressing your questions regarding our permit renewal application and hope to have a completed application to you soon. I do want to follow up on one item, because I am not clear how to respond.
>
> For your item #5: "Please respond directly to application questions 20.d. of the application. The current application response simply states "Question 10 has been completed."
>
> Question 20d in the application simply states: "Capture and restraint; if you will be capturing animals, ensure that you have completed question 10, above."
>
> This reads like a reminder rather than a question. So our response of "Question 10 has been completed" is simply acknowledging that we have read 20d, and completed question 10 as 20d instructs us to do.
>
> Please let me know if I am misinterpreting what 20d is saying.
>
> Thank you,
>
> Joe
>
> **Joe Tomoleoni**
> Biologist
> U.S. Geological Survey
> Western Ecological Research Center
> Santa Cruz Field Station
> 2885 Mission St.
> Santa Cruz, CA 95060
> 831.254.9750

BISON CONNECT

Vargas, Darcy <darcy_vargas@fws.gov>

Research Application # 672624

Vargas, Darcy <darcy_vargas@fws.gov> Wed, Apr 17, 2019 at 2:57 PM
To: Joe Tomoleoni <jtomoleo@ucsc.edu>
Cc: Brian Hatfield <brian_hatfield@usgs.gov>, "Yee, Julie" <julie_yee@usgs.gov>

Hi Joe,

I am happy to answer your questions.

Regarding question 20d, you are correct. I apologize for including that question on my list.

Regarding the table in the application question #21, column C (Level A or Level B Harassment) refers to the activity being requested to take place (listed in column B). Therefore, the level of harassment we are requesting refers to the activity being proposed to be done on the specific species being requested to work on (Southern sea otters).

Column H (Max. # non- target conspecifics incidentally harassed) refers to the maximum number of non-target species that could be incidentally harassed by your work being done (listed in column B). It is generally assumed that non-target species will be avoided when possible, but if you have a reason to knowingly take a non-target species and/or know that your activity (column B) will cause level A harassment to a non-target species, that is important information for us to know. However, to avoid confusion, please refer your level of harassment/take on the application table # 21 to the work/activity being proposed to be done on the sea otters. Additional information explaining a different level of take for non-target species could be explained in the text.

Please let me know if you have any additional questions.

Thanks,

Darcy Vargas
Biologist
US Fish and Wildlife Service
MS: IA
5275 Leesburg Pike
Falls Church, VA 22041-3803
www.fws.gov
www.cites.org

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Vargas, Darcy <darcy_vargas@fws.gov>

Research Application # 672624

Vargas, Darcy <darcy_vargas@fws.gov> Wed, Apr 17, 2019 at 4:20 PM
To: Joe Tomoleoni <jtomoleo@ucsc.edu>

Hi Joe,

While I was looking through your file answering your questions earlier today, I was having a difficult time finding copies of your 2016 & 2017 reports (I found your 2014 & 2015 reports though). Therefore, if you could include copies of your 2016 & 2017 reports when you provide your 2018 report, it would be very helpful.

Thank you,
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Vargas, Darcy <darcy_vargas@fws.gov>

Research Application # 672624

Joe Tomoleoni <jtomoleo@ucsc.edu> Thu, May 16, 2019 at 7:45 PM
To: "Vargas, Darcy" <darcy_vargas@fws.gov>
Cc: "Barry, Anna" <Anna_Barry@fws.gov>, Lilian Carswell <lilian_carswell@fws.gov>, Brian Hatfield <brian_hatfield@usgs.gov>, "Yee, Julie" <julie_yee@usgs.gov>, Joe Tomoleoni <jtomoleoni@usgs.gov>

Also, I've attached our 2018 permit report here, as requested.

Thank you,

Joe

Joe Tomoleoni
Biologist
U.S. Geological Survey
Western Ecological Research Center
Santa Cruz Field Station
2885 Mission St.
Santa Cruz, CA 95060
831.254.9750
jtomoleo@ucsc.edu

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2018 ANNUAL REPORT ON SOUTHERN SEA OTTERS_complete.pdf
21269K

Vargas, Darcy <darcy_vargas@fws.gov>

Research Application # 672624

Joe Tomoleoni <jtomoleo@ucsc.edu> Thu, May 16, 2019 at 7:36 PM
To: "Vargas, Darcy" <darcy_vargas@fws.gov>
Cc: "Barry, Anna" <Anna_Barry@fws.gov>, Lilian Carswell <lilian_carswell@fws.gov>, Brian Hatfield <brian_hatfield@usgs.gov>, "Yee, Julie" <julie_yee@usgs.gov>, Joe Tomoleoni <jtomoleoni@usgs.gov>

Hello Darcy and Anna,

Attached is a completed permit renewal application, revised as requested by Darcy in the email below. The only outstanding question we had that still remains unclear is the difference between Columns C & H in Table 2 (Question 21). Because today is the due date for the renewal application, I went ahead an interpreted this to the best of my ability. Column C represents the number of otters we are asking for permission to capture over the 5-yr duration of the permit (600 total captures), while Column H represents the total number of otters incidentally harassed during our captures (1,250) for the entire 5-year duration of the permit. Please note that we provided a second table (Table 3) that further clarifies how many otters we plan to capture, instrument, and incidentally harass.

The cover letter describes how the application has been modified to address Darcy's questions, and also describes how we plan to modify our procedures as a result of the October 2018 research-related mortality.

Please let us know if you have any additional questions.

Thank you,

Joe
Joe Tomoleoni
Biologist
U.S. Geological Survey
Western Ecological Research Center
Santa Cruz Field Station
2885 Mission St.
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831.254.9750
jtomoleo@ucsc.edu

On Mon, Apr 1, 2019 at 9:27 AM Vargas, Darcy <darcy_vargas@fws.gov> wrote:
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Combined_application_packet_2019May16.pdf
10540K

May 13, 2019

Dear Darcy and Anna:

Enclosed you will find our revised application for the renewal and amendment of our current permit #MA672624-20, addressing all of your questions from our email correspondence on April 1, 2019. Note that in order to make sure we have clearly answered your questions from the April 1 correspondence, we have included a section that specifically lists your questions and our responses, in addition to addressing each question in the actual application packet. The revised Application for Renewal (Form 3-200-43) is included along with 45 additional pages to Form 3-200-43 starting with Section E.

Please note that we are requesting that our new permit essentially remain the same as our previous permit with a few exceptions. We are requesting to add 8 additional co-investigators, all of whom are exceedingly qualified and important to our work. Their qualifications and CV's are found within. Furthermore, in an attempt to alleviate any confusion, we have eliminated language referring to the "carry-over" of takes from our previous permit. Instead, we are simply stating the number of takes that we are requesting in our new permit. It should be noted that the new number requested happens to be very similar to the amount of unused takes from our prior permit.

We also want to specifically address the issue of the research-related mortality in the Fall of 2018. We discuss this issue in several difference sections of the permit, but we would like to summarize here. First, it is important to note that the animal in question died more than 2 years post-capture, so the complications were not acutely related to the capture or surgery. Necropsy determined that both surgically implanted instruments (TDR & VHF) were entrapped in the omentum and resulted in a fatal twisting. It is believed that the TDR popped out of the falciform ligament and became free-floating, which resulted in a cascade of events that caused both instruments to become entangled. If the TDR would have remained in place in the falciform ligament, there is a reasonably good chance that this otter would have survived without serious complications. Because of this finding, and the fact that there have been other issues with free-floating TDR entrapment in the omentum, we are currently seeking to refine our surgical procedure to make sure that the TDR remains in the falciform ligament and does not become free-floating. Dr. Mike Murray, our chief veterinarian from the Monterey Bay Aquarium, has proposed a novel approach that involves the use of an extracellular matrix (ECM) pouch (which is routinely used in human surgeries) to create a more robust pocket for the TDR. Extensive testing would need to be done on captive sea otters at the Monterey Bay Aquarium, so Dr. Murray and the Aquarium are currently working on an amendment request to pursue this technique under their permit.

Additionally, we are currently pursuing new tagging technologies (described in more detail in our application) that will hopefully allow us to start moving towards the use of more external tags. It has long been our goal to reduce the invasiveness of our tagging tech, and we are currently developing an electronic flipper tag that with have GPS capabilities to provide sea otter location data. This tag could also feature a pressure sensor which may allow it to fill the role of the TDR.

We recognize that both of the above solutions (surgical modification and new tag tech) require thorough testing and cannot be rushed. Therefore, we are proposing that effective immediately, we will suspend internal implants of all TDRs while we continue to work diligently on the above alternatives. This is not a decision that we have made lightly. TDRs have been tremendously valuable tools for sea otter research and nearly everything we know today about sea otter dive behavior (and much of what we know about reproductive energetics) comes from TDRs. However, we have always put the health and welfare of our sea otters above all else, and we believe that we are continuing to act in the best interest of the sea otters by suspending traditional TDR implants until a safer solution is developed. We are hopeful that we will be able to return to utilizing TDRs in the future in a manner that is safer for the otters. All language referring to the implant of TDR instruments has been removed from the permit application, but we are still requesting the ability to remove TDRs that were previously implanted under our earlier permits.

In additional to the main permit application, we've included a full copy of our current ACUC. Please note that the previous UCSC IACUC that we submitted with the original application in August is no longer valid, and our new USGS ACUC is now included in this revised packet. A three-page list of relevant publications that have stemmed from previous versions of our current FWS permit is also included for your reference.

Three separate research proposals for sea otter studies that are currently in progress under our existing permit have been enclosed in accordance with question 18 in the application.

If you have any questions or require any additional information, please do not hesitate to contact myself or Brian Hatfield, of the U. S. Geological Survey. Contact information is as follows:

Joe Tomoleoni: 831-254-9750, jtomoleoni@usgs.gov
Brian Hatfield: 805-305-2121, brian_hatfield@usgs.gov

Sincerely,

Joseph Tomoleoni
Enclosure

TO DO FOR USFWS PERMIT

1. Provide a numerical response to the application question on Part I, # 7.b (pg. 5).
Maximum expected number of animals harassed from #7a = 0.

2. Respond to application question on Part I, # 7.c. (pg. 5).
We do not expect any non-target marine mammals or ESA-listed species to be taken as a result of our activities, so the expected maximum number is 0.

3. Respond to application question on Part I, # 8, and if applicable, # 8.h. and/or 8.i. (pgs. 5 & 6). #8 is NO (N/A for the subsections)

4. Please respond directly to application questions 20.a. of the application instead of referring to responses to other questions asked in the application. DONE

5. Please respond directly to application questions 20.d. of the application. The current application response simply states "Question 10 has been completed." Per Darcy, the response "Question 10 has been completed" is appropriate here.

6. Please respond directly to application questions 20.e. instead of referring to responses that could be found in *Lander et all* (2001). Each application question must have a direct response provided and the response should not reference information found in another location (a different application question, published paper, protocols, and/or enclosures). DONE

7. Please respond directly to application questions 20.f.iii, 20.f.iv, 20.f.v, 20.f.vi. of the application. The responses to these questions simply states "Refer to Table 1, above." DONE

8. Please respond directly to application questions 20.g.i, 20.g.ii, 20g.iii, 20.g.iv, 20.g.v. and 20.g.xiii. of the application. These questions were not responded to. All responded to but there is no 20.g.xiii

9. Please respond directly to application questions 20.hi. 20.h.ii, and 20.hiii. of the application. A general paragraph was provided, but none of these question were responded to directly. DONE. All captive work is done in collaboration with the Monterey Bay Aqurium, under the existing MBA captive research permit, and thus, we don't request any permission for captive work under our USGS permit.

10. In regards to question 20.i. of the application, please ensure to have provided all responses that you want reviewed directly in your response. It is noted that your response states to "see Table 1 for more information." However, we need clear and precise responses and therefore, we will not infer your response by reviewing the table. DONE

11. Your table provided in response to question 21 of the application is unclear. Why are the first 2 rows of the tables left black for rows c. through i.? Please provide an updated table that is completed in entirety and that reflects your current and complete application requests. This table has been adjusted for clarity. In order to simplify, we removed all references to the number of remaining takes on our current permit, and are simply stating how many takes we are requesting for this renewal. There was still some confusion on the difference between Column C and H. We interpreted those two columns as follows: Column C represents the number of otters we are asking for permission to capture over the 5-yr duration of the permit (600 total captures), while Column H represents the total number of otters incidentally harassed during our captures (1,250) for the entire 5-year duration of the permit. Please note that we provided a second table (Table 3) that further clarifies how many otters we plan to capture, instrument, and incidentally harass.

12. Respond to question 22. of the application in entirety. The application response states "this has already been addressed in Question 10, section h." However, it is unclear as to what you are referring to by Section H of the application and regardless, each application question must be responded to directly. DONE

13. Regarding female-pup calf pairs, your application clearly identifies that research is intended to be conducted on the pairs. Therefore, please clarify how impacts would be minimized. Pups weighing less than 11 pounds won't be flipper tagged. Will anything else be done? The response to question 23 states that "very small pups are generally avoided when attempting to capture sea otters."   Another application response states that pups 1-2 weeks of age won't be targeted, yet your application requests to work on all age classes. Those responses contradict each other. Therefore, please provide updated and consistent application responses regarding research proposed to be done on pups and female-calf pairs. Also, ensure to responds directly to application questions requesting information on what procedures are being requested for each activity via age class and what precautions would be taken. DONE and clarified.

14. Please respond directly to question 25 of the application and explain how the research will involve the lease possible degree of pain without referencing other documents. The application response states "refer to methods in Question 10 and in this most recent section ,a as well as our IACUIC SOPs, and numerous published peer-review papers provided in this application." DONE. Outside references removed, details expanded upon.

15. Respond to question 29.a. through 29.j. of the application and provide the requested table, in table format. New table created to answer these questions.

16. Respond to application question 29.k.vi. of the application in entirely. The application response states "N/A."   However, the application response also confirms that samples will be from wild animals. Therefore, a response to the question

is required because intrusively collected samples are being proposed to be taken from wild sea otters. This question is applicable for our review purposes. DONE

17. Respond to application question 29.l. in entirety. The application response states "Refer to Table 1, and the additional information provided in (k), above." DONE

18. Please clarify your responses to application questions 20 and 30. The following names were included in the application response to names of personnel who will conduct the sampling. However, these same names were not included in your list of all personnel that will be involved in the project: Cara Field, Shawn Johnson, Clarie Simeone, Dave Casper, Marissa Yound, and Michelle, Staedler. Michelle was on previous permits so is not new. We have listed 8 people that we are requested to be added to the permit. CVs for all personnel (new and exsiting) are attached in this packet

19. The cover letter enclosed with the application package states that the only amendment being requested is to add 3 personnel to the project. However, the application responses do not support that statement. Therefore, please provided a final confirmation of all personal whom are being requested to be included as co-investigators.

- Question 30 of the application requests to add Zachary Randell as a new co-investigator. However, he was included on USGS's previously issued permit.
- The following personnel were not included as amendments to add as co-investigators and were not included in the application response to question 30. However, these names were included in the list of personnel who will conduct the sampling (pg. 25 of the application enclosure). They were not previously included on USGS's permit. Therefore, they appear to be new amendment requests.

  --Shawn Johnson (DMV)
  --Cara Field (DMV)
  --Claire Simeone (DMV)
  --Marissa Young
  --Michelle Staedler

Michelle Staedler has been on all previous versions of this permit and is not new. We are requesting that Shawn Johnson, Cara Field, Claire Simeone, Marissa Young, Julie Yee, Nicole Thometz, Dave Casper, and Tim Tinker be added to the permit.

20. CVs were provided for Zachary Randell, Tim Tinker, and Dave Casper. Thank you. However, you must also provide the CVs for every other PI and co-investigator (including samplers) being requested to be included in this renewal and amendment application. Also, please understand that we will not reference or look for CVs included as part of previously submitted applications.
All CVs for all personnel are included in the packet.

21. Please provide your 2018 report.
Included in the packet.

Department of Interior
U.S. Fish and Wildlife Service

Federal Fish and Wildlife Permit Application Form

U.S. Fish and Wildlife Service
Division of Management Authority
Branch of Permits, MS: IA
5275 Leesburg Pike
Falls Church, VA 22041-3803
1-800-358-2104 or 703-358-2104

Type of Ac ivity

Take/Import/Export of Marine Mammals for Public Display, Scientific Research, Enhancement, or Rescue/Rehabilitation/Release Activities or Renewal/Amendment of Existing Permit (*MMPA and/or ESA*)

Complete Sections A or B, and C, D, and E of this application. U.S. address may be required in Section C, see instructions for details.
You may find instructions on how to make your application complete and help avoid unnecessary delays at the following link:

Section A: Complete if applying as an individual

1.a. Last Name		1.b. First Name	1 c. Middle Name/Initial	1.d. Suffix
Tomoleoni		Joseph	A	
[redacted]	3. Telephone Number	3.a. Alternate Telephone Number	4. E-mail address	
	831-254-9750		jtomoleoni@usgs.gov	

Section B: Complete if applying on behalf of a business, corporation, public agency, Tribe, or institution

1.a. Name of business, agency, Tribe, or institution		1 b. Doing business as (DBA)	
2. Tax identification no.		3. Description of business, agency, Tribe, or institution	
4.a. Principal officer Last name	4.b. Principal officer First Name	4.c. Principal officer Middle name/initial	4.d. Suffix
5. Principal officer title	6. Primary contact name		
7.a. Business telephone number	7.b. Alternate telephone number	7.c. Business fax number	7.d. Business e-mail address

Section C: All applicants complete address information

1.a. Physical address (Street address; Apartment #, Suite #, or Room #; no P.O. Boxes)				
2885 Mission Street				
1.b. City	1.c. State	1 d. Zip code/Postal code	1 e. County/Province	1.f. Country
Santa Cruz	CA	95060	Santa Cruz	USA
2.a. Mailing address (include if different than physical address; include name of contact person if applicable)				
2.b. City	2.c. State	2 d. Zip code/Postal code	2 e. County/Province	2.f.Country

Section D: All applicants MUST complete

1. Attach the **non-refundable application processing fee,** in he form of a check or money order, payable to the U.S. FISH AND WILDLIFE SERVICE **in the amount identified on page 3**. Federal, Tribal, State, and local government agencies, and those ac ing on behalf of such agencies, are exempt from the processing fee – *attach documentation of fee exempt status as outlined in instructions.* [50 CFR 13.11(d)].
2. Certification: I hereby certify that I have read and am familiar with the regulations contained in ***Title 50 Part 13 of the Code of Federal Regulations*** and he other ***applicable parts in subchapter B of Chapter I of Title 50***, and I certify that the information submitted in this application for a permit is complete and accurate to the best of my knowledge and belief. I understand that any false statement herein may subject me to the criminal penalties of 18 U.S.C. 1001.

Signature of applicant/Principal Officer for permit (No photocopied or stamped signatures)   Date of signature (mm/dd/yyyy)

Please continue to next page

E. Take/Import/Export of Marine Mammals for Public Display, Scientific Research, Enhancement, or Rescue/Rehabilitation/Release Activities or Renewal/Amendment of an Existing Permit (Species listed in the MMPA and/or species listed in both the MMPA and ESA)

Allow at least 90 days for the application to be processed. Applications for marine mammal permits must be published in the Federal Register for a 30-day public comment period.

Use this application for the take[1], import, export, or re-export of marine mammal species (or their parts) under the jurisdiction of the U.S. Fish & Wildlife Service (sea otters, marine otter, polar bears, walrus, manatees, and dugongs; see the marine mammal policy fact sheet) for purposes of public display of live animals, scientific research, or enhancement under the U.S. Marine Mammal Protection Act (MMPA) and/or U.S. Endangered Species Act (ESA). This application may also be used to apply for a letter of authorization (LOA) under MMPA Sections 109(h)/112(c) and/or an ESA permit for enhancement of propagation or survival of the species, which would provide authorization to work as a "cooperator" for the purpose(s) of **rescue, rehabilitation, and/or release of stranded marine mammals.** Finally, this application may be used for the **renewal and/or amendment** of an existing permit for these activities.

Note: Renewal and amendment requests require responses to all questions pertaining to your requested activity.

This form should NOT be used:

- For activities involving marine mammals under jurisdiction of the National Marine Fisheries Service (NMFS) (i.e., whales, dolphins, porpoises, seals, and sea lions), please contact NMFS.
- For activities involving photography in the wild for educational or commercial purposes, use Form 3-200-86.
- For transport/transfer of live captive-held animals within the United States, use Form 3-200-87.
- For transfer within the United States of dead marine mammal specimens for the purpose of public display or scientific research, use Form 3-200-87.

If you already have MMPA/ESA authorization and need a CITES permit:

- For CITES export/re-export of captive-held **LIVE** animals, use Form 3-200-53.
- For, export, or re-export of parts or biological samples, use Form 3-200-29; for import of parts of Appendix-I animals, use Form 3-200-37; and for introduction from the sea, use Form 3-200-31.
- Provide a copy of your FWS or NOAA Fisheries permit or authorization with your CITES permit application.

All international shipment(s) must be through a designated port. A list of designated ports (where an inspector is posted) is available from the list of designated ports. If you wish to use a port not listed, please contact the Office of Law Enforcement for a Designated Port Exemption Permit (form 3-200-2).

[1] The term, "take," as defined by the MMPA means to harass, hunt, capture, or kill, or attempt to harass, hunt, capture, or kill any marine mammal. As defined by the ESA, "take" means to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct.

PERMIT TYPES AND PROCESSING FEES

Please review the complete application carefully before beginning. Provide complete answers to all the questions in the sections relevant to the activity for which you are requesting authorization. If a question is not applicable, answer with "N/A." You will need to use additional sheets of paper. On all attachments or separate sheets you submit, indicate the application question number you are addressing. If you are applying for multiple species and/or activities, be sure to indicate which species/activity(ies) you are addressing in each response.

Electronic submission of inventories, photographs, and receipts: Some applications contain extensive inventories and/or a large number of photographs or receipts. You may provide electronic versions of the documents. Such a submission will assist in the processing of your application since it may reduce data entry by the U.S. Fish and Wildlife Service. If you wish to provide information electronically, once you have received an application number via the e-mailed acknowledgement letter, e-mail your information to Permits@fws.gov. Be sure to include the application number provided in the acknowledgement e-mail that will be sent to you when we receive your application.

☐ **I will be submitting documents electronically.**

PURPOSE for which you are applying (check below):

☐ PUBLIC DISPLAY of live animals (Processing Fee = $**300**): **Complete All of Part I and Part II**.

NOTE: A public display permit is not available for marine mammal species listed as depleted under the MMPA or listed under the ESA; a public display permit may be valid for the life of an animal and is not renewable; a public display permit may be available for a facility that would hold multiple animals of a particular species and would be renewable every 5 years.

☑ SCIENTIFIC RESEARCH (Processing Fee = $**150**): **Complete All of Part I and Part III**.

☐ RESCUE, REHABILITATION, and/or RELEASE of stranded marine mammals (Processing Fee = $**150**):
Complete questions 1-7 of Part I and Part IV.

☐ MMPA ENHANCEMENT of survival or recovery of the species or stock (Processing Fee = $**150**):
Complete Part I and Part V.

Request is for (check below):

☐ NEW PERMIT (See processing fee above).

☑ RENEWAL of Permit # MA672624-2 (See processing fee above; Complete all questions for your requested activity, as described above).

☐ AMENDMENT of Permit # ____________ (For Scientific Research, Rescue/Rehabilitation/Release, or MMPA enhancement, amendment fee = $75, and for Public Display = $150).

If requesting renewal or amendment of your current permit, provide an update of any activity that has occurred under the permit since your last report.

PART I.

1. Name and address where you wish the permit to be mailed, **if different from page 1**. If you would like expedited shipping, please enclose a self-addressed, pre-paid, computer-generated, courier service airway bill. If unspecified, all documents will be mailed via the U.S. Postal Service.

   same address as Page 1

2. Who should we contact if we have questions about the application (name, phone number, and e-mail)?

   First contact: Joseph Tomoleoni, 831-254-9750, jtomoleoni@usgs.gov
   Secondary contact: Brian Hatfield, 805-305-212, bhatfield@usgs.gov

3. Disqualification factor. A conviction, or entry of a plea of guilty or nolo contendere, for a felony violation of the Lacey Act, the Migratory Bird Treaty Act, or the Bald and Golden Eagle Protection Act disqualifies any such person from receiving or exercising the privileges of a permit, unless such disqualification has been expressly waived by the Service Director in response to a written petition. (50 CFR 13.21(c)) Have you or any of the owners of the business, if applying as a business, been convicted, or entered a plea of guilty or nolo contendere, forfeited collateral, or are currently under charges for any violations of the laws mentioned above?

   ☐ No ☐ Yes

   If you answered "Yes" to Question 3, provide: a) the individual's name; b) date of charge; c) charge(s); d) location of incident; e) court; and f) action taken for each violation. Please be aware that a "Yes" response does not automatically disqualify you from getting a permit.

4. List the scientific name (genus, species, and, if applicable, subspecies), and common name of each species for which you are applying.

   Enhydra lutris nereis, Southern sea otter

5. Provide a copy of any other applicable Federal, local, or state permissions (e.g., National Wildlife Refuge Special Use Permit, NOAA National Marine Sanctuary permit, etc.) required to conduct your proposed work, OR indicate whether you have applied for, secured, or will apply for such permissions (please provide contact information).

6. Is/are the species or population stock(s) for which you applying listed under the U.S. Endangered Species Act (ESA), a species proposed for listing, or a candidate species?

   ☐ **NO** ☐ **YES;** complete a-d, below.

   a. Attach a justification for taking an ESA-listed species, and explain why your proposed activities are not appropriate for a similar non-ESA-listed species;

   b. Describe both the short- and long-term anticipated effects of each of your activities alone or cumulatively on the behavior and physiology of the target animals and critical habitat or proposed critical habitat for the species.

c. Describe how the animals will react to your actions and the consequences of those reactions.

see attached pages

d. Identify how you would mitigate any potential negative effects.

see attached pages

7. Do you plan to conduct activities with **MARINE MAMMALS IN THEIR NATURAL ENVIRONMENT (**i.e., in the wild) where "non-target" marine mammal and ESA-listed species occur in the United States? ("Non-target" species are species that are not the subject of your activities.)

☐ **NO** ☐ **YES**; We will need to assess impacts to marine mammal and ESA-listed species that are not the subject of your activities; therefore, provide responses to a-c, below:

a. A list of all non-target marine mammals and ESA-listed species that might occur in your project area or might be affected by your activities;

see attached

b. The maximum number of animals of each non-target marine mammal and ESA-listed species (# per species) that might be harassed by your activities, the precautions that you will take to minimize the likelihood that harassment will occur, and the actions that you will take should harassment occur; and

see attached

c. The maximum number of animals of each non-target marine mammal and ESA-listed species (# per species) that might be taken (e.g., killed, injured, feeding activities disrupted, etc.) by your activities, your precautions to minimize the likelihood that take will occur, and your actions should take occur.

We do not expect any non-target marine mammals or ESA-listed species to be taken as a result of our activities, so the expected maximum number is 0.

(Note: The following link provides access to resources that might be useful to you in gathering the required information to answer this question, including links to FWS and NMFS offices responsible for managing marine mammals stocks, and Stock Assessment Reports, which provide population status information on marine mammal stocks.

8. Do you plan to conduct your public display, research, or MMPA enhancement activities with **MARINE MAMMALS that are CURRENTLY HELD IN A CAPTIVE ENVIRONMENT (including, but not limited to import into the U.S. of captive-held live animals/specimens)**

☐ NO ☐ YES; specify the number of captive individuals for each species of interest: _____and for each individual animal of each species of interest, respond to a-g, h and i below.

Note: You may provide the information in tabular form, as in the example below:

a. Species	**b.** Sex	**c.** Birth date	**d.** Description (e.g., ID #, ISIS #, transponder #, tattoo #)	**e.** Country of origin	**f.** Source (i.e., wild, captive-born, or captive-bred)	**g.** Current location of animal
Example: *Enhydra lutris kenyoni*	Female	Approx. 04/09/2010	House # XXX123 Transponder # 45678	USA	wild	ABC Aquarium, Anchorage Alaska

h. For **captive-born or captive-bred animal(s)**, provide a breeder's statement, ARKS/ZIMS specimen report, or other information that documents the animal was born in captivity, location of birth, and information on the source of the parental stock (e.g., captive-born, wild).

i. For **captive-held animal(s) already taken from the wild**, provide:
   i. Information (e.g., ARKS/ZIMS specimen report(s)) on the source of the animal, including when the animal was removed from the wild, by whom, and the location.
   ii. A copy of the MMPA permit or LOA under which the animal is currently being held in captivity or a copy of the MMPA permit or authorization authorizing removal of the animal from the wild.
   iii. Has the U.S Fish and Wildlife Service deemed the animal(s) non-releasable to the wild?

☐ **YES**; provide a copy of the official letter confirming the animal's non-releasable status.

☐ **NO**; if you are requesting to have the animal(s) deemed non-releasable at this time, provide an explanation of the following: a) why release of the animal to the wild will not likely be successful given its physical condition; b) why release of the animal to the wild will not likely be successful given its behavior including adverse interactions with humans or marine mammals; **or** c) why release of the animal to the wild may jeopardize the wild population of the species.

9. For animal(s) to be taken from the wild and brought into a captive environment for public display, research, or MMPA enhancement activities, provide for each species:

   a. Information on the actual or proposed date(s) and location(s) of collection;
   b. The numbers of animals of each age class and sex to be taken from the wild (include a definition of each of these age classes by range of # months and/or years).
   c. An estimate of the species' population stock in the wild; Note: stock assessment reports might assist you with this information and are available at the following FWS field offices, depending on the species involved:

      Southern sea otter: Ventura Fish and Wildlife Office

      Northern sea otter: Washington Fish and Wildlife Office

      Northern sea otter, walrus, polar bear: Marine Mammals Management, AK

      Manatee: North Florida Ecological Service Office

   d. A description of the efforts made to acquire captive-held animals, in lieu of taking animals from the wild.

(Note: for holding and maintaining animals you must also provide the information requested in question 14.)

10. Are you requesting to **CAPTURE LIVE** marine mammals in the wild? (i.e., for research, public display, or MMPA enhancement)

☐ NO ☐ **YES**; specify the number of individuals to be captured for each species of interest: up to 600 and provide a – i, below:

a. A description of the manner in which the animal will be captured, type of gear used, and deployment method (e.g., from shore or boat approach and net deployment).
b. Methods of restraint and holding, including dimensions/type of holding container, if used;
c. The holding time required prior to transport or release of the animal;
d. Number and roles of personnel participating in the captures;
e. Duration of restraint/holding from capture to release; and
f. The number of non-target individual animals of the target species that will be incidentally harassed during capture activities, and precautions you will take to minimize incidental harassment of non-target animals;
g. If capturing females with calves/pups/cubs, describe:
   i. How calves/pup/cubs will be held;
   ii. Which procedures will be conducted on them;
   iii. The duration of time the pair will be separated; and
   iv. Procedures used to reunite the pair, and if they do not reunite, explain the disposition of the calf/pup/cub.
h. A description of the use of drugs during capture, including:
   i. Name of each drug/chemical used, its dosage rate (ml/kg), method of administration (IV, IM, SQ, topical and whether remotely-deployed IM), and purpose of the drug;
   ii. Duration of drug and required holding time;
   iii. The names of the personnel who would administer the drugs;
   iv. Provisions to minimize adverse reaction(s), including the use of appropriate drug reversals;
   v. Procedures to be used to minimize the chance that drugged animals will escape or enter the water prior to complete immobilization; and
   vi. Measures to be taken to ensure that the animal is fully recovered prior to release.
i. What emergency procedures would be employed (e.g., drugs, bagging, CPR, etc.) in the event that an animal's condition starts deteriorating during capture activities?

11. Are you requesting to **IMPORT LIVE** marine mammals?

☐ NO ☐ **YES**; specify the number of individuals to be imported for each species of interest: ____________ and provide a – m, below:

a. The proposed date of import;
b. The name and address of the foreign exporter, including the country of export;
c. For wild-sourced animal(s), a description of the manner in which it was taken from the wild and a copy of the foreign collecting/capture authorization(s);
d. The age (approximate or known) of the animal at the time of removal from wild or from its mother;
e. The age (approximate or known) of the animal at time of weaning; and
f. For females, respond to i & ii, below:
   i. At the time of removal from the wild, was the female pregnant? ☐ NO ☐ YES
   ii. At the time of the proposed import, will the female be pregnant? ☐ NO ☐ YES
g. A description of the means and duration of the transportation used to move and import the animals;
h. A description of the type, size, and construction of all shipping containers used to transport the animals;
i. A description of the arrangements for watering or otherwise caring for the animals during transport;
j. A description of the qualifications of each person accompanying the animal that demonstrates their ability to address the animal's needs during transport;
k. A copy of the transport plan;

l. Quarantine plans, including location and time-frame; and
m. Any additional documentation showing compliance with U.S. Department of Agriculture (USDA) regulations for transport and care of live marine mammals (7 U.S.C. 2131-2159; 9 CFR 3, Part E).

NOTE: A separate CITES permit will be required from our office prior to the import of live CITES Appendix I species.

12. Are you requesting to **IMPORT PARTS/SPECIMENS** of/from marine mammals?

☐ **NO** ☐ **YES**; provide a – m, below:

a. The proposed date of import;
b. The name and address of the foreign exporter, including the country of export;
c. The current location of the specimens;
d. The country of origin of the animals from which the specimens were/will be collected;
e. List the number of animals by species, age class/life stage, and sex from which parts/samples are sought. If you are requesting opportunistic sample import, you may request an unlimited number of samples from a specified number of animals, by taxa (e.g., unlimited samples from up to 100 polar bears annually).
f. The types of specimens to be imported (e.g., blood, skin biopsy, carcasses, etc.) and number of each type from each animal;
g. The source of the specimens to be imported (wild, captive-bred, or captive born);
h. Were the animals/will the animals be alive or dead at the time of sample collection?

☐ DEAD ☐ LIVE

i. Provide a detailed description of the source of the specimens to be imported and the manner in which the sample was/will be taken or collected. For example, this might include the following sources:
   i. Animals in captivity (samples taken during routine husbandry procedures or under separate authorization; distinguish between permanently captive in public display or research facility or temporarily captive in rehabilitation facility);
   ii. Animals in foreign countries stranded alive or dead or that died during rehabilitation;
   iii. Animals killed during legal subsistence harvests;
   iv. Animals killed incidental to legal commercial fishing operations;
   v. Samples from other authorized researchers or collections;
   vi. Soft or hard parts that are sloughed, excreted, or discharged naturally.
j. Provide a copy of the foreign collecting/capture authorization(s) (if not required, indicate “not required”);
k. If importing samples from subsistence-hunted marine mammals in foreign countries, describe the subsistence method. Include documentation, if available, that verifies that the taking was/will be conducted in a humane manner (i.e., using the method that involves the least possible degree of pain and suffering);
l. If importing samples from live animals, describe how the samples were/will be collected, including animal handling and sample collection protocols. This should include a description of how the take was humane; and
m. Describe how the specimens will be preserved, shipped, and stored/curated.

NOTE: A separate CITES permit will be required from our office prior to the import of specimens of CITES Appendix I species.

13. Are you requesting to **EXPORT or RE-EXPORT PARTS/SPECIMENS** of/from marine mammals?

☐ **NO** ☐ **YES**; provide a – e, below:

a. The types of specimens and quantity of each to be exported/re-exported;
b. The complete name and address of person/facility receiving the specimen(s);
c. A description of the origin of the specimens to be exported/re-exported;
d. The name(s) of the facility/institution that currently holds the specimens; and
e. Whether a portion of the specimen will need to be re-imported following export/re-export.

NOTE: A separate CITES permit will be required from our office prior to the export/re-export)

14. Are you a facility requesting **MAINTENANCE of LIVE ANIMALS (**i.e., holding and caring for animals) for public display, research or MMPA enhancement activities?

☐ **NO** ☐ **YES**; specify the number of individuals to be held for each species of interest: ________________;

and provide a – h, below:

a. A complete description, including photographs and/or diagrams (no blueprints), of the area and facilities where the animals will be held (including the dimensions of pools and haul-out areas);
b. The number of animals of the same species (include age and sex) presently maintained at the facilities and information indicating whether there is space for additional animals without exceeding USDA/Animal and Plant Health Inspection Service (APHIS) limits (i.e., provide the maximum # of animals of each species that could be held).
c. A list of all animal caretakers and a description of their specific duties/responsibilities;
d. A description of the animal caretakers' experience in the care, handling, and maintenance of the marine mammal species that is/are the subject of this application and copies of curriculum vitae (CVs) that demonstrate such experience for each caretaker;
e. A description of specific State requirements regarding who (e.g., attending veterinarians, vet technicians, researchers) may handle and administer certain drugs;
f. A list of all marine mammals under the jurisdiction of FWS maintained at the facility (specify whether they are held in the same exhibit/holding area as the target animals will be held and maintained);
g. A description of all deaths of FWS-jurisdiction marine mammal species at the facility within the past five years and the steps taken to prevent or decrease similar mortalities;
h. A copy of the facility's USDA/APHIS, Animal Welfare Act (AWA) license and the most recent APHIS inspection report.

15. If you are a facility requesting maintenance of live animals for which the primary purpose is scientific research, or enhancement of survival or recovery of the species, are you seeking approval to publicly display the subject animals?

☐ **NO** ☐ **YES**; in a-c, below, provide information to show that:

a. The facility is open to the general public without limitations or restrictions (other than by the charging of an admission fee);
b. The facility offers a program for education or conservation purposes that is based on professionally recognized standards of the public display community; and
c. Such display will not interfere with attainment of the objectives of the permitted/authorized activity.

PART II.

FOR PUBLIC DISPLAY

16. For U.S. facilities, provide information to show that the facility:
    a. Is open to the general public without limitations or restrictions (other than by the charging of an admission fee);
    b. Offers a program for education or conservation purposes that is based on professionally recognized standards of the public display community (include copies of outreach/educational materials and photos of signage); and
    c. Is registered or holds a license issued by the USDA Animal and Plant Health Inspection Service (APHIS) under the Animal Welfare Act (AWA).

PART III.

FOR SCIENTIFIC RESEARCH

17. Explain how the proposed research meets the MMPA definition of "bona fide research," i.e., scientific research on marine mammals, the results of which: (A) are likely to be accepted for publication in a referenced scientific journal; (B) are likely to contribute to the basic knowledge of marine mammal biology or ecology; or (C) are likely to identify, evaluate, or resolve conservation problems.

    see attached.

18. Provide a detailed description of the proposed project. You may attach a formal research proposal, provided it includes all the requested information, including:

    a. Objectives and hypotheses and associated methodology;

    b. Background information discussing relevant published literature on the subject of your proposal, with citations;

    c. An explanation of how this study is different from, builds upon, or duplicates past research;

    d. An explanation of how you determined your sample size/take numbers (e.g., based on previous encounter rates or abundance estimates for the study area). If appropriate for your study, include a power analysis or other sample size estimation to show whether the sample size is sufficient to provide statistically significant or otherwise robust results appropriate for your study;

    e. If proposing novel procedures, include a discussion on results from pilot studies or studies on other species, if available; and

    f. Disposition of animals or remaining specimen material once your project is complete.

19. Provide the expected research schedule (clearly specify the proposed start date and end date of your research or field season(s) and overall duration of the project). Include the months of the year and frequency of fieldwork/sampling (e.g., number of times per year). If your research extends beyond five years, or is a continuation of previously authorized research, give information about when the research began and when you expect it to end.

Level A harassment means any act of pursuit, torment, or annoyance, which has the potential to injure a marine mammal or marine mammal stock in the wild.

Level B harassment means any act of pursuit, torment, or annoyance, which has the potential to disturb a marine mammal or marine mammal stock in the wild by causing disruption of behavioral patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering.

Take, as defined by the MMPA means to harass, hunt, capture, or kill, or attempt to harass, hunt, capture, or kill any marine mammal.

20. Indicate which research procedures/activities you will be conducting that will or might result in **TAKE or HARASSMENT of TARGET species**, and describe each activity in detail, including the information indicated in a-i, below.

   a. Administration of drugs (including emergency drugs and prophylactic antibiotic use) or other substances (e.g., stable isotopes); include i-vii, below, in your activity description:
      i. Name of each drug/chemical used, its dosage rate (ml/kg), method of administration (IV, IM, SQ, topical and whether remotely-deployed IM), and purpose of the drug;
      ii. Duration of drug and required holding time;
      iii. The names of the personnel who would administer the drugs;
      iv. A description of specific State requirements regarding who (e.g., attending veterinarians, vet technicians, researchers) may handle and administer certain drugs;
      v. Provisions to minimize adverse reaction(s), including the use of appropriate drug reversals;
      vi. Procedures to be used to minimize the chance that drugged animals will escape prior to complete immobilization; and
      vii. Measures to be taken to ensure that the animal is fully recovered prior to release.

   b. Aerial and vessel surveys (manned); include i-v, below, in your activity description:
      i. Type of survey craft and vessel;
      ii. Type of survey (e.g., line transect, photogrammetry);
      iii. Number of surveys per year;
      iv. Minimum and maximum altitude/approach distance; and
      v. Duration spent with group or individual per day.

   c. Aerial surveys using unmanned aircraft systems (UAS); include i-xii, below, in your activity description:
      i. Dimensions, mass, and battery life of UAS;
      ii. Will the UAS ever be beyond the line of sight?
      iii. Does the device have an auto-return feature should the device fail?
      iv. Ground control station description (what it is, where it will be located, e.g., on shore or on vessel, number of stations, and how close the station will be to animals);
      v. Spotter roles (e.g., one spotter monitoring the UAS, another for monitoring the ground control station);
      vi. Do you have the appropriate FAA permits/authorizations (including pilot licenses)?
      vii. Type of survey (e.g., line transect, photogrammetry);
      viii. Number of surveys per year;
      ix. Minimum and maximum altitude/approach distance;
      x. Duration spent with group or individual per day;
      xi. The names of the personnel who will pilot the aircraft, and
      xii. Mitigation measures you will use to minimize disturbance including specific measures you will use to avoid separating female-calf/pup/cub pairs, and measures to ensure the UAS will not collide or crash into any of the animals.

   d. Capture and restraint; if you will be capturing animals, ensure that you have completed question 10, above.
   e. Instrumentation, Marking, and Tagging (MTI); include i-x, below, in your activity description:
      i. The type of MTI (including dimensions and mass);
      ii. The maximum number and total mass of MTIs to be attached to/implanted in an animal at a given time;
      iii. The maximum dart penetration depth if MTI is attached via darts;
      iv. Methods and location of attachment, including minimum approach distance for remote MTI attachment;
      v. If surgeries for implantable tags are being conducted, specify who will be conducting them, where (in the field or in a facility), and if antibiotic prophylactics will be administered;
      vi. The maximum number of times an animal would be fitted with MTIs in a given year;
      vii. Will recapture be necessary (if so, how many times will animals be captured annually), would the instrument/tag have a release mechanism, or would the instrument/tag fall off?

viii. Have the proposed MTIs been used previously on this species?
ix. What are the potential adverse effects and the means of monitoring new MTIs for adverse effects?
x. What actions will be taken in the event that the MTI has a significant adverse impact on the animal(s), and what is the method of animal release from the MTI?

f. Intrusive sampling (e.g., blood, blubber, muscle, skin); include i-xiii below, in your activity description:
i. Will sampling be remote or under restraint?
ii. Will local anesthetics be administered?
iii. Type of tissues sampled;
iv. Size or volume of sample (diameter and depth or total volume);
v. Target sampling location on body;
vi. Maximum number of samples per animal per day and per year;
vii. Sampling intervals (e.g., for serial blood or biopsy samples);
viii. Collection method and equipment/materials used (e.g., dart fired from rifle, dart depth, sterilization/disinfection);
ix. If remote, what is the minimum approach distance?
x. If restrained, describe treatment of site of sample collection (e.g., cleansing, wound left open or closed);
xi. Number of attempts per animal per day (include total number of attempts needed for all work if requesting multiple procedures (e.g., remote tagging and biopsy) on same animal on the same day);
xii. The names of the personnel who will conduct the sampling; and
xiii. Sample preservation and analysis.

g. Non-intrusive sampling (e.g., behavioral observations via focal follows and ground surveys, scat collection, passive acoustic monitoring and recording, photo-ID, photogrammetry, remote video monitoring, underwater photography); include i-vi, below, in your activity description:
i. Approach, sampling methods, and platform type;
ii. Minimum and maximum approach distance (specify different distances for each deployment method);
iii. Are researchers within sight of animals or not (e.g., from a blind)?
iv. Frequency of observations/sampling;
v. Duration of observations/sampling per day; and
vi. If conducting underwater photography/videography, specify the method (e.g., snorkeling, underwater pole cam, or divers using typical gear or rebreathers) and number of people in the water at a given time, including the safety diver/snorkeler.

h. Testing methodologies on captive-held animals; include i-iii, below, in your activity description:
i. A description of the methodologies and equipment to be used;
ii. Duration and times of testing and data analyses; and
iii. Methods used to decondition the animals that will be released to the wild after testing.

i. Other procedures/activities; list each additional procedure/activity and provide a detailed description of each, including all appropriate mitigation measures (note, we might contact you with follow-up clarification of methodologies), novel procedures, and any procedures involving active acoustic or hearing studies).

21. **For each procedure/activity**, provide the information in a-j, below, including the maximum number of animals of each species expected to be taken by the procedure annually, broken down by sex and age class; the number of takes per animal per year; and an estimate of the number of animals of the study species that might be incidentally harassed (i.e.,# of non-target animals of your study species that might be harassed by your activities). Also, include the time-periods and specific locations of the takes. This information may be provided in table format such as:

a. Species	b. Procedure/ Activity	c.Level A or Level B Harassment*or other Take**	d.Age Class(see question 23, below)	e. Sex	f.Max. # Animals Per Year	g.Max. # Takes Per Animal Per Year	h.Max. # non-target conspecifics incidentally harassed	i.Time-period	j. Location

*** Level A harassment** means any act of pursuit, torment, or annoyance which has the potential to injure a marine mammal or marine mammal stock in the wild. **Level B harassment** means any act of pursuit, torment, or annoyance which has the potential to disturb a marine mammal or marine mammal stock in the wild by causing disruption of behavioral patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering.

****Take**, as defined by the MMPA means to harass, hunt, capture, or kill, or attempt to harass, hunt, capture, or kill any marine mammal.

22. Will any female-pup/calf/cub pairs be targeted for any of the proposed research activities? If so, describe how you would minimize impacts on pups/calves/cubs and associated females during each of those activities.

23. Define each age class listed in your response to question 21(d), above, for each species (i.e., list the range of months or years (or mass for otters) constituting each age class); provide the minimum age (or mass) that animals will be targeted for take activities; and indicate whether females with calves/pups/cubs less than that minimum age will be targeted for take activities?

24. Describe the precautions that will be taken to minimize the likelihood that harassment of non-target individuals of the study species will occur and the actions that will be taken should harassment occur.

25. Explain how you determined that your methods involve the least possible degree of pain and suffering and why there are no feasible alternative methods to obtain the desired data or results.

26. Provide: a) an estimate of the possible number of unintentional deaths or serious injuries that might result from your research activities; b) the number of unintentional and intentional (via euthanasia for humane purposes if an animal is seriously injured) deaths or serious injuries you seek approval for annually; c) the steps you will take to reduce the likelihood of deaths or injuries; and d) if euthanasia might occur, provide the method of euthanasia (e.g., gunshot, drug, etc.) and who would conduct the euthanasia procedure.

27. In the event of a death, will a necropsy be conducted on the animal?
☐ NO ☐ YES

28. If a female animal accompanied by calf/pup/cub(s) dies during research activities, specify the disposition of the associated calf/pup/cub(s).

29. If biological samples are to be collected or received domestically, provide responses to a through j, below, for each individual animal per species. This information, or part of the information, may be provided in table format such as the table below. (Note: if your **only** proposed activity is to transfer dead marine mammal specimens for purposes of public display or scientific research, complete application Form 3-200-87).

a. Species	b. ID #	c. Sex	d. Source (Wild or Captive/ Live or Dead)	e. Birth Date or age class	f. Type of Samples (blood, tissue, DNA)	g. Number of animals sampled annually	h. Number of times each animal will be sampled annually	i. Packaging and Preservation of samples	j. Use/ Disposition of Samples

k. Provide a detailed description of the source of the specimens, including the circumstances under which the animals were/will be taken. For example, this might include the following sources:
   i. Animals stranded alive or dead;
   ii. Animals killed during legal subsistence harvests;
   iii. Animals killed incidental to legal commercial fishing operations;
   iv. Samples from other authorized researchers or collections;
   v. Soft or hard parts that are sloughed, excreted, or discharged naturally;
   vi. Samples that will be/were intrusively collected from captive-held animals;
   vii. Samples that will /were collected from wild animals.

l. If collecting samples from live animals, describe how the samples were/will be collected, including animal handling and sample collection protocols.

m. For samples received domestically from U.S. permitted researchers, include the researcher's name, affiliation, and permit number under which samples will be/were collected.

(Note: if samples are to be imported, you must answer question 12, above).

30. Provide a list of all personnel that will be involved in the project, identifying each as either a principal investigator or co-investigator, their project duties/responsibilities, and a brief description or CV that demonstrates their experience and expertise to perform their designated duties, including knowledge of the marine mammal species that is/are the subject of this application.

31. Describe how you will collaborate or coordinate with other researchers in your study area. Who are they? Explain how this will occur and how it will minimize negative impacts on the species. For example, will it involve sharing resources, samples or data; timing surveys to minimize disturbance, etc.?

32. If you intend to conduct research on animals in a captive-holding facility such as a zoo or aquarium, provide documentation showing that the facility(ies) has authorized you to conduct your proposed activities.

33. Animal Welfare Act (AWA) Compliance (for research on live animals only): AWA requirements apply to all research facilities, which include institutions, organizations, or people that use or intend to use LIVE animals in research, tests, or experiments; AND, that receive funds under a grant, award, loan, or contract from a department, agency, or instrumentality of the U.S. for the purpose of carrying out research, tests, or experiments, or acquires or transports the animals in commerce. **Provide the following documentation:**

    a. Registration under the AWA as a research facility:
        i. Attach a copy of your APHIS certificate of registration as a research facility, or for Federal facilities, a letter from your Institutional Officer that you are compliant with applicable requirements for scientific research under the AWA; **OR**
        ii. If your facility does/will not conduct activities requiring registration under the AWA, attach a letter from APHIS confirming that registration is not required.
    b. Institutional Animal Care and Use Committee (IACUC) documentation: If your facility is registered as a research facility under the AWA or is a Federal research facility (see a.i), attach the applicable IACUC documentation from the list in i-iii, below. Please note that all activities that involve an invasive procedure, harm, or materially alter the behavior of an animal under study, even if the activities are carried out in the field, are subject to IACUC review and approval. See (AWA regulations and standards for definition/explanation of covered research activities.):
        i. Attach a copy of your final protocols with the IACUC signed approval; **OR**
        ii. Attach a copy of your proposed protocols to be reviewed by your IACUC along with an explanation as to how and when the protocols will be reviewed (Note: A copy of your final signed protocols and certification will be required prior to permit issuance.); **OR**
        iii. Attach the IACUC determination that your research activities are not subject to IACUC review and approval.
    c. If your facility is not registered as a research facility under the AWA, please provide an explanation of how your take activities are reviewed and monitored to assure that the proposed takes are humane (i.e., using the method that involves the least possible degree of pain and suffering).

PART IV.

FOR RESCUE, REHABILITATION, AND/OR RELEASE OF STRANDED[2] MARINE MAMMALS (☑ CHECK IF NOT APPLICABLE)

Marine mammals may be captured from the wild by duly authorized U.S. Fish and Wildlife Service personnel or **authorized cooperators** for the protection or welfare of the marine mammal or for the protection of public health and welfare and held at cooperating authorized facilities. This section of the application is for those parties interested in applying for a letter of authorization (LOA) under MMPA Sections 109(h)/112(c). Parties interested in rescue, rehabilitation, and release activities involving ESA-listed marine mammals would also use this section of the application to apply for an accompanying ESA permit for enhancement of propagation or survival of the species OR to apply as a "sub-permittee" working under the authority of an ESA permit held by different organization or agency. Authorized "sub-permittees" would be responsible for coordinating their activities with the designated ESA permit-holder (i.e., "Permittee") and would be required to comply with the conditions of that permit. Each authorized party's MMPA LOA will document the ESA permit number associated with that LOA, whether the party is a sub-permittee or the Permittee on the ESA permit.

The MMPA LOA or, for ESA-listed species, the combined MMPA LOA and ESA permit would provide authorization for individuals or institutions to work as "cooperators" for the purpose(s) of rescue, rehabilitation, and/or release of stranded marine mammals. Marine mammal rescues are dangerous activities that require trained staff, specialized equipment, and clear communication among stranding partners. The U.S. Fish and Wildlife Service provides opportunities for different levels of involvement for approved cooperators: verifiers, rescuers, transporters, critical care facilities, and rehabilitation/holding facilities. These roles are defined in question 37, below.

34. Are you/your organization currently conducting research activities with marine mammals?

☐ **NO** ☐ **YES; provide the permit number under which you are conducting research____________.**

35. What type of authorization are you requesting (check all that apply)?

☐ LOA under MMPA Sections 109(h)/112(c)

☐ ESA permit for enhancement of propagation or survival of the species

☐ Sub-permittee under ESA permit #__________________.

36. What type of stranding event are you requesting to respond as a cooperator for a U.S. Fish and Wildlife Service marine mammal rescue, rehabilitation, and release program?

☐ OIL SPILL EVENTS

☐ OTHER CONTAMINANT SPILL EVENTS; SPECIFY TYPES______________________________.

☐ OTHER STRANDING EVENTS

[2] The term, "stranding," as defined by the MMPA means an event in the wild in which: (A) a marine mammal is dead and is on a beach or shore of the United States or in the waters under the jurisdiction of the United States (including any navigable waters); OR (B) a marine mammal is alive and is on a beach or shore of the United States and unable to return to the water, on a beach or shore of the United States and, although able to return to the water, is in need of apparent medical attention, or in the waters under the jurisdiction of the United States (including any navigable waters), but is unable to return to its natural habitat under its own power or without assistance.

37. Indicate at which level(s) of responsibility the cooperator will participate (Check all that apply, and respond to the questions below).

☐ **VERIFIER:** The role of verifiers is limited to answering requests to provide physical verification of the condition of reported live, distressed animals and communicating the location and status of an animal to the appropriate person(s), including the rescue program coordinator and, if so directed, the nearest approved rescue facility. In most cases verifiers are required to stay with the animal until an approved rescue and transport team arrives. No physical interaction with animals is authorized under this designation. Verifiers may handle animals only under the guidance of an onsite designated rescue team(s).

a. Describe your organization's experience in verifying the condition of reported live, distressed or injured animals of each species requested (e.g., years of experience, number of responses, etc.).

b. Describe the qualifications of each of your staff who would be serving as a verifier in your organization that demonstrates their ability to verify the condition of reported, live, distressed animals of each species requested (including any work and/or volunteer experience that describes where, with what authorized organization, approximate number of hours, approximate number of verifications, and other relevant experience). Resumes, curriculum vitae (CV), and other supporting documents may be used to describe qualifications, including experience with the marine mammal species (or another similar marine mammal species) that is/are the subject of this application.

c. List and describe any specialized training that your staff have completed to perform this duty, including where and when the training occurred, which organization provided the training, types of training, and other relevant information.

d. Describe numbers and types of:

a) vehicles (cars, trucks, boats, etc.) that will be used to travel to/from locations of reported, live, distressed animals;

b) communications devices that will be used to communicate with rescue responders (phones, radios, etc.); and;

c) any other related equipment.

e. Provide a statement that you will be available to respond to reports of live, distressed animals of the subject species when needed.

☐ **RESCUER**: Rescuers respond to reports of injured and/or distressed animals and can initiate hands-on rescue and transport efforts as needed. This level of involvement requires substantial expertise and training in species-specific rescue techniques. Rescuers must meet U.S Department of Agriculture (USDA) standards for Humane Handling, Care, Treatment, and Transportation of Marine Mammals when rescuing live animals.

a. Describe your organization's experience in rescuing distressed or injured animals of each species requested (e.g., years of experience, number of rescues, etc.).

b. Describe the qualifications of each of your staff who would be serving as a rescuer in your organization that demonstrates their ability to rescue distressed animals of the subject species (including any work and/or volunteer experience that describes where, with what authorized organization, approximate number of hours, approximate number of rescues, and other relevant experience). Resumes, CVs, and other supporting documents may be used to describe qualifications, including experience with the marine mammal species (or another similar marine mammal species) that is/are the subject of this application.

c. List and describe any specialized training that your staff have completed to perform this duty, including where and when the training occurred, which organization provided the training, types of training, and other relevant information.

d. Describe how you meet or exceed USDA standards. Include a description of the number and types of:
   i. vehicles (cars, trucks, boats, etc.) that will be used to support the rescue of distressed animals;
   ii. rescue equipment (nets, stretchers, etc.) that will be used for rescues;
   iii. communications devices that will be used during rescues (phones, radios, etc.); and
   iv. any other related equipment.

e. Describe your methods of capture of the species of interest, including:
   i. Methods of restraint and holding, including dimensions/type of holding container, if used;
   ii. Minimum number of personnel participating in captures at any given time;
   iii. Precautions you will take to avoid separating female-calf/pup/cub pairs, and protocol in the event they are separated, including disposition of the separated calf/pup/cub; and
   iv. Precautions you will take to minimize incidental harassment of non-target animals of the target species.

f. Provide a statement that you will be available to respond to reports of live, distressed animals when needed.

☐ **TRANSPORTER:** Transporters respond to reports of injured and/or distressed animals and initiate transport

efforts as directed. This level of involvement requires substantial expertise and training in the species-specific transport methodology, as well as, the necessary equipment and trained staff to accompany and move the animals to or between approved critical care and/or rehabilitation/holding facilities. Transporters must meet U.S Department of Agriculture (USDA) standards for Humane Handling, Care, Treatment, and Transportation of Marine Mammals when transporting live animals. Transports must also be consistent with Animal Welfare Act requirements for transportation and USFWS transport regulations.

a. Describe your organization's experience in transporting animals of each species requested (e.g., years of experience, number of transports, etc.).

b. Describe the qualifications of each of your staff in your organization who would be accompanying animals during transport, demonstrating their ability to transport, accompany, and support animals of the subject species (including any work and/or volunteer experience that describes where, with what authorized organization, approximate number of hours, approximate number of transports, and other relevant experience). Resumes, CVs, and other supporting documents may be used to describe qualifications, including experience with the marine mammal species (or another similar marine mammal species) that is/are the subject of this application.

c. List and describe any specialized training that your staff have completed to perform this duty, including where and when the training occurred, which organization provided the training, types of training, and other relevant information.

d. Describe how you meet or exceed USDA standards:

   i. Include a description of the number and types of: a) vehicles (trucks, boats, airplanes, etc.) that you will use to transport animals of the subject species; shipping containers that will be used to transport the animals (including type, construction, dimensions, and weight); other equipment that will be used in the transport of the animals (foam pads, water sprayers, stretchers, etc.); communications devices that will be used during transports (phones, radios, etc.); and any other related equipment.

   ii. Describe how the subject animals will be cared for during transport, including the number of attending staff and a description of the arrangements for watering or otherwise caring for the animals during transport.

e. Provide a statement that you will be available to transport animals of the requested species when needed.

☐ **CRITICAL CARE FACILITY**: These facilities hold and medically treat sick and/or injured animals whose lives would be jeopardized if care were not provided. These facilities have the species-specific equipment, experience and credentials necessary to rescue, stabilize, rehabilitate and release animals. These facilities may also provide long-term care, as needed, for generally healthy animals awaiting release, or they may provide long-term care for those individuals designated as “non-releasable”. Critical care facilities must meet or exceed USDA standards for Humane Handling, Care, Treatment, and Transportation of Marine Mammals when maintaining, treating, and holding live animals.

a. Describe your organization’s experience in maintaining, holding, and caring for distressed or injured animals of each species requested (e.g., years of experience, number of animals held, etc.).

b. Describe the qualifications of each of the staff in your organization who would be caring for, handling, and maintaining animals of the subject species (including any work and/or volunteer experience that describes where, with what authorized organization, approximate number of hours, approximate number of animals, and other relevant experience). Resumes, CVs, and other supporting documents may be used to describe qualifications, including experience with the marine mammal species (or another similar marine mammal species) that is/are the subject of this application.

c. For authorization as a critical care facility, you must have a qualified, critical care veterinarian. Provide the name of the person assigned this role and describe his/her qualifications, including a CV or resume that demonstrates his/her ability to perform this role.

d. Describe how you meet or exceed USDA standards. Include a description of:
   i. critical care and holding areas, including descriptions of holding tanks and haul-out areas. The description should include photographs, drawings, and/or diagrams illustrating the area(s) and facility (or facilities) where animals of the subject species will be held. When describing holding tanks, include dimensions (tank length, width, depth, water volume); describe pumps and filtration systems in tanks (including type and capacity and other relevant information); describe lifting apparatus; describe water heaters (including degree to which tanks can be heated); describe water source and type (and ability to use freshwater, saltwater and/or both); and any other relevant features.
   ii. The maximum number of animals of the subject species that can be housed at your facility.
   iii. The current distribution and number of animals of the subject species by holding tank at your facility (include sex, age (if known), time in captivity, age/size class, calves/pups/cubs, etc.).
   iv. All deaths of the subject species at your facility within the past five years and the steps taken to prevent them.

e. Describe quarantine plans, including location and time-frame.

f. Provide a copy of i) your USDA Animal and Plant Health Inspection Service (APHIS) Animal Welfare Act (AWA) license; and ii) your most recent APHIS inspection report.

g. Provide a statement that you will be available to maintain, care for, and house animals of the subject species when needed, including round the clock veterinary care.

☐ **REHABILITATION/HOLDING FACILITY:** These facilities provide routine husbandry for generally healthy

animals that require a minimum of specialized treatments. These facilities may provide long-term care, as needed, for generally healthy animals awaiting release, or they may provide long-term care for those individuals designated as non-releasable. Holding facilities must meet USDA standards for Humane Handling, Care, Treatment, and Transportation of Marine Mammals when holding live animals.

a. Describe your organization's experience in maintaining and holding animals of each species requested (e.g., years of experience, number of animals held, etc.).

b. Describe the qualifications of each of the staff in your organization who would be caring for, handling, and maintaining animals of the subject species (including any work and/or volunteer experience that describes where, with what authorized organization, approximate number of hours, approximate number of animals, and other relevant experience). Resumes, CVs, and other supporting documents may be used to describe qualifications, including experience with the marine mammal species (or another similar marine mammal species) that is/are the subject of this application.

c. For authorization as a holding facility, you must have a qualified veterinarian. Provide the name of the person assigned this role and describe his/her qualifications, including a CV or resume that demonstrates his/her ability to perform this role.

d. Describe how you meet or exceed USDA standards. Include a description of:
   i. holding areas, including descriptions of holding tanks and haul-out areas. The description should include photographs, drawings, and/or diagrams illustrating the area(s) and facility (or facilities) where animals of the subject species will be held. When describing holding tanks, include dimensions (tank length, width, depth, water volume); describe pumps and filtration systems in tanks (including type and capacity and other relevant information); describe lifting apparatus; describe water heaters (including degree to which tanks can be heated); describe water source and type (and ability to use freshwater, saltwater and/or both); and any other relevant features.
   ii. The maximum number of animals of the subject species that can be housed at your facility.
   iii. The current distribution and number of animals of the subject species by holding tank at your facility (include sex, age (if known), time in captivity, age/size class, calves/pups/cubs, etc.).
   iv. All deaths of the subject species at your facility within the past five years and the steps taken to prevent them.

e. Describe your facility's quarantine plans, including location and time-frame;

f. Provide a copy of i) your USDA Animal and Plant Health Inspection Service (APHIS) Animal Welfare Act (AWA) license; and ii) your most recent APHIS inspection report.

g. Provide a statement that you will be available to maintain and house animals of the subject species when needed.

h. Are you seeking approval to display the animals while holding and maintaining them for rehabilitation purposes?
___**NO** ___**YES**; in i-iii, below, provide information to show that:

i. The facility is open to the general public without limitations or restrictions (other than by the charging of an admission fee);
ii. The facility offers a program for education or conservation purposes that is based on professionally recognized standards of the public display community; and
iii. Such display will not interfere with attainment of the objectives of the permitted/authorized activity.

PART V.

FOR MMPA ENHANCEMENT OF SURVIVAL OR RECOVERY OF A SPECIES OR STOCK

Note: This section of the application should not be completed unless you are specifically requesting MMPA Enhancement activities (e.g., this section is not intended for those parties requesting to conduct rescue, rehabilitation, and release activities for marine mammals).

38. Provide information to show that your proposed activities are likely to contribute significantly to maintaining or increasing the distribution or population numbers necessary to ensure the survival or recovery of the species or stock in the wild.

39. Provide information to show that your proposed activities are consistent with any conservation or recovery plan for the species or stock, or, if no plans are available, that the activity is consistent with the actions required to enhance the survival or recovery of the species or stock and that would be addressed in a conservation or recovery plan. For activities that involve captive maintenance of live animals:

a. Provide an explanation on the benefit of removing animals from the wild into captivity; and
b. Include a description of plans in place for returning animals and any offspring to the wild.

(Note: You must also provide the information requested in question 14, above.)

SECTION E.

If requesting renewal or amendment of your current permit, provide an update of any activity that has occurred under the permit since your last report.

Since our last annual report (which included all activities in calendar year 2017), we have captured and flipper tagged 5 female southern sea otters. Four of these were adult and one was a subadult. Two of these sea otters (1 adult and 1 subadult) received radio transmitters. All 5 animals were captured off the Monterey Peninsula in March 2018.

PART I

5. Provide a copy of any other applicable Federal, local, or state permissions (e.g., National Wildlife Refuge Special Use Permit, NOAA National Marine Sanctuary permit, etc.) required to conduct your proposed work, OR indicate whether you have applied for, secured, or will apply for such permissions (please provide contact information).

Not Applicable

6. Is/are the species or population stock(s) for which you applying listed under the U.S. Endangered Species Act (ESA), a species proposed for listing, or a candidate species?

Yes.

a. Attach a justification for taking an ESA-listed species, and explain why your proposed activities are not appropriate for a similar non-ESA-listed species;

The USGS is the agency responsible for research on sea otters, a DOI trust species. Sea otters are protected under the MMPA and in some areas of their range (including California) are listed as threatened under the ESA. The USGS sea otter research project was initially established in the 1970's, has been operating continuously since then (through changes in personnel and in agencies where the project has resided), and is the primary agency responsible for conducting sea otter research. For some controlled studies (e.g, laboratory research), mink or ferrets may be used as a surrogate species for sea otters; however, for studies of sea otter populations in the wild, there is no suitable surrogate.

b. Describe both the short- and long-term anticipated effects of each of your activities alone or cumulatively on the behavior and physiology of the target animals and critical habitat or proposed critical habitat for the species.

Based on the results of our past research, we are able to gain some insight into both physiological and behavioral effects of capture/sampling/tagging/surgery over the short and long term. As far as substantial physiological effects that may affect survival rates, our data suggest that these are not substantial enough so as to be measurable: this assertion is based on a number of published demographic analyses (Siniff and Ralls, 1991; Tinker et al 2006; Tinker et al 2008) that estimate survival rates from radio tagged animals, and then compare these vital rate estimates with independent estimates derived from the age structure of the death assemblage, as well as the expected vital rates given the observed rate of population growth. Based on these comparisons, it appears that the radio-tagged cohorts exhibit the same age/sex specific survival and reproductive rates as the population as a whole (or if there is a difference, it is too small to be measurable).

As far as more subtle behavioral and physiological impacts of our activities, we have two data sets that we can use to infer that there are indeed significant, though transient, effects: 1) observational data on time-activity budgets and foraging behavior, and 2) data from archival time-depth recorders on dive behavior and core body temperature. In both cases, the data suggest a range of individual responses: at one extreme, some animals return to a regular pattern of feeding activity and core body temperature ranges within 24 hours of the surgical implantation of instruments (Fig 1 A,B), while at the other extreme some animals may exhibit slightly reduced (or occasionally elevated) temperatures and reduced diving activity for 2-7days post-surgery (Fig 1 C,D). Most animals fall somewhere between these two extremes: for animals that do exhibit a prolonged recovery time, the short term effects include reduced activity, elevated temperature and likely some mass-loss due to reduced feeding. The longer term effects for such animals are more difficult to gauge: because these animals return to typical activity levels within 1-2 weeks, and (in the case of females) go on to successfully gestate and raise pups (M. Staedler, 2010, Master's Thesis, UCSC), we infer that any long term effects of our activities fall within the normal range of physiological challenges dealt with by wild sea otters. Examination of the surgical sites on study animals that die (for reasons unrelated to our activities, e.g. shark bite or disease infections) and undergo thorough necropsies suggest that the surgical wounds are entirely healed within 30 days of the surgical intervention (Dr. M. Miller, CDFW, Dr. M. Murray, MBA, pers. comm.). In a very small number of cases, there may be some entanglement of one or both of the implanted instruments within the omentum (a tissue layer within the abdominal cavity): this condition is very rarely life threatening to the animal, although it may in some cases affect the ability of the omentum to respond to other "problems" within the abdominal cavity, such as intestinal parasites that burrow through the intestinal wall. Such conditions are very infrequent, having been observed in only a handful of cases out of many hundreds of animals that have undergone this procedure.

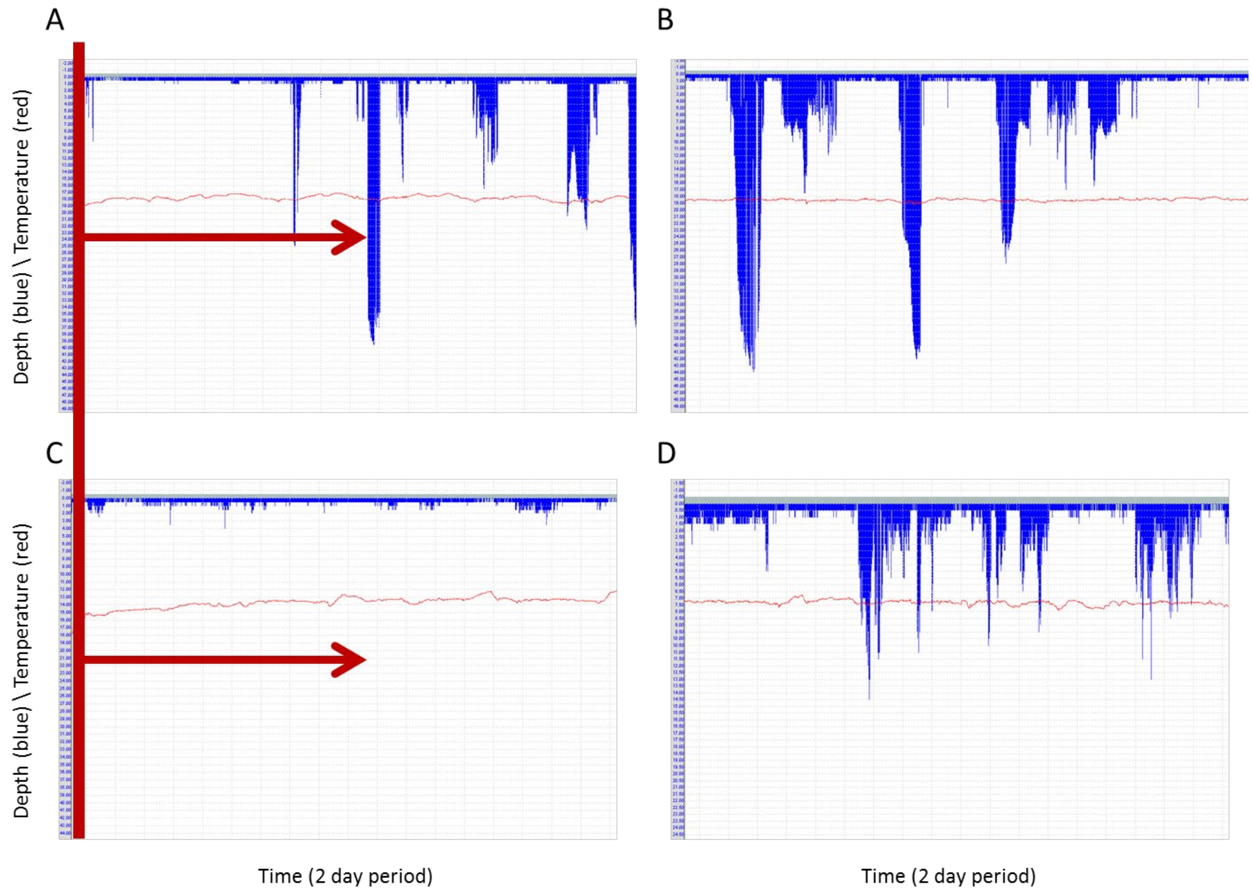


Figure 1. *Time-depth-temperature profiles from two adult female sea otters captured in Monterey. In all 4 plots, dive profiles are shown in blue (vertical depth axis scale is held constant, with surface at top and 45m depth at bottom), temperature profiles are shown in red (vertical temperature axis scale is held constant), and the horizontal axis is time (48 hours are shown in all cases). Two 48-hour periods are shown for female 1 at top and two 48-hour periods are shown for female 2 at bottom. The plots on the left hand side (A, C) depict diving activity and temperature immediately after surgical implantation of the instrument (the dark red vertical band shows time of implanting, the horizontal red arrow shows a 24 hour period after surgery). The plots on the right hand side depict diving activity and temperature on typical days 2 months later for each animal. Female 1 resumes normal diving activity and temperature within 24 hours (compare A to B), while female 2 exhibits reduced diving activity and slightly depressed temperature for the first 48 hours after surgery (compare C to D).*

c. Describe how the animals will react to your actions and the consequences of those reactions.

See attached USGS ASC IACUC-approved SOP: Sea Otter Capture, Chemical Immobilization, Routine Sampling, and Routine Surgery for more details on the following activities.

Capture of sea otters results in potential disturbance to animals that are in close proximity to captured animals but are not captured themselves. Tangle nets offer the greatest potential disturbance of the capture methods used while dip-netting and diver captures generally cause less disturbance. Because most captures will be by divers and median or average group sizes are between 1-3 otters, a reasonable approximation of disturbance would be 50-200% of the number actually captured. However, disturbance is of very short duration, less than 30 minutes, as the transport vessel arrives and departs quickly from the capture location. This incidental disturbance is similar to that caused by other boats (recreational, fishing, etc) operating in close proximity to sea otters. Precautions to minimize incidental disturbance will be to vacate the capture location as quickly as possible, avoid targeting large groups if possible, approach and depart via routes that do not interfere with foraging or traveling otters or other resting groups, and to stop using an area for a day or longer after a few disturbances have occurred (whether from successful captures or unsuccessful attempts). If harassment does occur, we will vacate the area as soon as possible to allow the otters to return to their normal behaviors.

Individual sea otters have variable reactions to our capture attempts. Most attempt to flee, though some individuals put up very little resistance. Their reaction to our capture attempts undoubtedly causes some degree of stress, as with any animal capture. We go to great lengths to minimize stress and handling time with these animals (see section D, below) by using experienced personnel and custom designed equipment, and our decades of research demonstrates that the reactions of the captured sea otters are acute/temporary, and once released, normal behavior is resumed, usually within 24 hours.

d. Identify how you would mitigate any potential negative effects.

It starts with our approach to capturing sea otters. The boat does not approach the animals directly and keeps a suitable distance away from the target otters. Disturbing or causing the otters to react is counterproductive to our entire capture effort, so we ensure that the otters are kept unaware of our presence until the moment of capture. Using divers whenever possible further prevents negative reactions from otters, since they are not becoming entangled in a net or being chased by a boat. The divers use highly advanced technology by employing oxygen rebreathers which vent no bubbles and are completely silent. These are the same rebreathers that are used by combat divers like NAVY SEALs in order to remain completely undetected. Not only does this technology increase our effectiveness, but being undetected by the otters also means that they do not react to our presence until absolutely necessary (at the moment of capture).

Once captured, the otters are transferred to a specialized holding box that has been custom designed to minimize stress and maximize comfort of the captured otter. The boxes are made of plywood and provide a dark space, which calms the animal. The boxes also have numerous holes in the sides and bottom which allows for air ventilation. These holes also permit the box to be partially submerged in the water, allowing the otter to thermoregulate using the cold sea water to combat any increase in body temperature that might result during the capture process. In our decades of experience employing this technique, the otters are remarkably calm once in the holding box. The box also has a PVC "false bottom" that allows any debris or fouling material such as feces to pass through the bottom and exit the box, keeping the inside of the box clean of any substance that could potentially foul the otter's coat.

Any negative effects of animal processing (collecting morphometric data, blood or tissue samples, and/or surgical implantation of instruments) are minimized by sedating the sea otter, so it is unaware of the procedures that are occurring. The sedative also has a minor short-term memory loss component associated with it, which will help the animal to forget the encounter once released, reducing any sort of stress that could possibly occur after release.

7. Do you plan to conduct activities with MARINE MAMMALS IN THEIR NATURAL ENVIRONMENT (i.e., in the wild) where "non-target" marine mammal and ESA-listed species occur in the United States? ("Non-target" species are species that are not the subject of your activities.)

a. A list of all non-target marine mammals and ESA-listed species that might occur in your project area or might be affect by your activities

<u>Marbled Murrelet (Brachyramphus marmoratus)</u>
<u>California Least Tern (Sterna antillarum browni)</u>
We anticipate that our activities will have no effect on marbled murrelets or least terns. In our experience, they are rarely encountered during our sea otter captures. We represent no greater risk to either of these species than any other boat on the water. In fact, we are less likely to affect murrelets because we are often traveling at slow speeds close to shore, where we are unlikely to encounter this species. The risk of encounter is even lower for least terns since they spend more time in flight and less time on the surface of the water than murrelets. Most likely, an encounter with least terns would involve the terns flying over or near our boats, resulting in no discernable impact to either terns or murrelets.

<u>Leatherback Sea Turtle (*Dermochelys coriacea*)</u>
<u>Olive Ridley Sea Turtle (*Lepidochelys olivacea*)</u>
We anticipate little to no impact on these chelonid species. Though leatherbacks do occur occasionally in these waters, they are almost always found in an open ocean/pelagic environment. We conduct our research in nearshore, shallow environments and are unlikely to ever encounter a sea turtle. Though tangle nets may represent a hazard to sea turtles in areas with dense turtle populations, we only set our nets in shallow waters, usually in or around kelp, where sea turtles are unlikely to occur. Although the scenario of a sea turtle getting caught in an otter tangle net is extremely unlikely, our protocols set forth in section 12(b) above, combined with our proposed amendment to the tangle net protocols in 12(b) insures that we will be able to quickly recognize and respond to an event where a turtle or any other non-target species becomes entangled in a net. Additionally, tangle nets are rarely used in California. Our

primary capture method of using diver-operated Wilson Traps and dip nets, due to their precise and selective nature, presents no risk to either species of sea turtle.

Steelhead (Oncorhynchus (=Salmo) mykiss)

Steelhead do occur in coastal waters off Central California, but our operations represent little to no risk to this species. Our primary capture methods (diver-operated Wilson Trap and dip netting) represent zero risk to this species. Tangle nets could potentially represent a risk to larger steelhead if the nets are set near creeks where steelhead run. As mentioned above, tangle nets are rarely used in California and thus any interaction with this gear and steelhead is unlikely. However, we would take care not to set nets in close proximity to the mouths of known steelhead streams. Also, our protocols set forth in section 12(b) above, combined with our proposed amendment to the tangle net protocols in 12(b) insures that we will be able to quickly recognize and respond to an event where any large non-target species becomes entangled in a net. In many years of otter captures in California, not a single steelhead has ever been caught in a tangle net.

Blue Whale (Balaenoptera musculus)
Humpback Whale (Megaptera novaeangliae)
Southern Resident Killer Whale (Orcinus orca)

These three species of cetaceans do occur off the Central California coast, with the humpback whale being the most common of the three. Realistically, our sea otter capture techniques do not present a risk to blue, humpback, or killer whales. These whales are usually encountered off shore or in deeper water, while we are almost always working in very shallow, nearshore waters. Though we do see humpback whales occasionally, they are usually far away from any kelp forests or locations where we are trying to catch sea otters. With that said, we always exercise common sense when deploying a tangle net. If there is a high amount of cetacean activity in the vicinity, we would choose not to deploy a tangle net in that area. In the extremely unlikely event that one of these whales were to become entangled in a net, the procedures (including the proposed amendment) set forth in Section 12(b) insure that we would be able to notice the problem immediately (perhaps even before it happens) and respond quickly to either prevent entanglement or free the entangled animal.

Other marine mammal species that reside in our study area and could be impacted include: California sea lion (*Zalophus californianus*), Harbor Seal (*Phoca vitulina*), Bottlenose Dolphin (*Tursiops truncates*), Harbor Porpoise (*Phocoena phocoena*), Risso's Dolphin (*Grampus griseus*), and Gray Whale (*Eschrichtius robustus*).

These species, though not Federally-listed, are marine mammals that do occur in the vicinity of the Central California coast where we will be working. The impact of our operations on these species should be minimal. As previously mentioned, the use of diver-operated Wilson Traps and dip nets, by their precise and selective nature, present no risk to these marine mammals or any other species mentioned in this section. The use of tangle nets, however, does pose a slightly elevated risk to these smaller marine mammals. We minimize the risk by rarely using tangle nets in California. Still, there are rare times when tangle nets must be deployed. In such instances we take care not to deploy the nets if there is an abundance of non-target marine mammals (such as seals, sea lions, or dolphins) in the area. In the unlikely event that a non-target marine mammal should become entangled in the net, the protocols set forth in the tangle net methodology section 12(b), combined with the amendment proposed in section 12(b), insures that we will be able to notice and respond quickly if a non-target marine mammal were to become entangled in a net. Researchers would do everything in their power (including cutting the tangle net) to release the animal as quickly as possible. Given the low frequency of tangle net usage compared to our other techniques (Wilson Traps and Dip Nets), combined with the precautions taken when using tangle nets, we expect that the likelihood of our sea otter capture operations impacting other marine mammal species would be very low.

b. The maximum number of animals of each non-target marine mammal and ESA-listed species (# per species) that might be harassed by your activities, the precautions that you will take to minimize the likelihood that harassment will occur, and the actions that you will take should harassment occur;

In general, we do not expect to harass Federally-listed species or non-target marine mammals, so the maximum expected number of animals harassed from part 7a = 0 for all species listed. The techniques of capturing otters by diver-operated Wilson Trap and dip net are very selective, precise, and accurate. This allows us to avoid harassing any species but the specific otters that we are targeting. The use of boats to conduct our work presents no greater risk to non-target species than any other boat on the water. In fact, our boats probably present less risk because we are diligent observers of marine life, we are usually moving at very slow speeds, and we generally work in shallow nearshore waters. When using tangle nets, the risk of harassment of non-target species increases, but remains extremely low.

Despite the low risk of harassment, we still take numerous precautions when using tangle nets. The deployment of nets is made under due consideration of predicted weather conditions: nets will not be set during periods of weather or sea state that may preclude their tending. Unlike in Alaska, tangle nets will very rarely be used in California, and only under circumstances where their use will (in the best judgment of the permit holder) represent a significantly lower risk of disturbance to sea otters and/or other marine mammal species. In cases where tangle nets are deployed we will also deploy 2 shore-based observers to monitor the nets and the entire vicinity of the nets (with a high-powered spotting scope) in order to detect the presence of non-target marine mammals. If there is detection of a non-target marine mammal, the nearby tending skiff will be called in to either pull the net or else remain beside the net until the marine mammals have left the area entirely. Additionally, at the time of net deployment, buoy-type floats will be attached to the float line at regular intervals (~10m apart) to increase the visibility of the float line and thus the likelihood that a shore-based observer with a telescope who was scanning that float line would be able to detect if even a small section of the net became pulled under water, signaling a possible entanglement. In such a case the tending skiff would be called in immediately to investigate (and release an entangled animal if that were the case). We believe both of the previously mentioned advanced monitoring techniques nearly eliminates the likelihood for unintended harassment of non-target marine mammals. At the very least, these protocols enable us to respond quickly and effectively, should unintended harassment occur.

c. The maximum number of animals of each non-target marine mammal and ESA-listed species (# per species) that might be taken (e.g., killed, injured, feeding activities disrupted, etc.) by your activities, your precautions to minimize the likelihood that take will occur, and your actions should take occur.

We do not expect to take any of the non-target marine mammal or ESA-listed species from #7a, so the expected maximum number = 0

10. Are you requesting to CAPTURE LIVE marine mammals in the wild? (i.e., for research, public display, or MMPA enhancement)

YES.

a. A description of the manner in which the animal will be captured, type of gear used, and deployment method (e.g., from shore or boat approach and net deployment).

Individual sea otters will be captured either in tangle nets, underwater diver-held traps (Wilson traps), or hand-held dip nets. All methods are routinely used throughout the range of the sea otter population (U.S., Russia, and Canada). Recapture of individuals will most likely be by underwater diver-held traps.

<u>Diver-operated Wilson Traps</u>

Our primary capture method involves using diver-operated traps to capture resting sea otters. Shore spotters with high-powered spotting scopes relay information about target animals to the dive crew. Divers work in pairs and each diver has a trap with a capacity for one adult sea otter, 2 juveniles, or a mother/pup pair. Otters must be resting (preferably sleeping) for this method to be successful. Divers use closed-circuit oxygen rebreathers and electric propulsion vehicles to maneuver the traps underneath the floating sea otters and engulf them with a net bag, which is closed by a purse line. The divers keep the animal and trap on the surface until the transport vessel arrives and the otters can be transferred to a sliding-lid capture box. Our research group has captured >600 sea otters in California, and >1000 sea otters in California, Alaska, Washington, Canada, and Russia combined, using diver operated Wilson traps with no trap-related mortalities. This method is highly selective, with zero chance for taking non-target species. Furthermore, this method allows us to target specific individuals, minimizing disturbance or harassment to non-target individuals.

<u>Tangle Nets</u>

Tangle nets are surface floating, un-weighted nets set in near shore waters in the vicinity of sea otters. Nets are typically 100 m long by 5 m deep (stretch mesh of about 22 cm), but may be modified to capture in shallow water. Each tangle net consists of stretch mesh hung between a positively-buoyant float line and a slightly negatively buoyant led line, and are suspended between large float buoys at each end which are anchored in place (ensuring sufficient anchor-line scope to avoid dragging the buoys below the surface under any tide or current condition). Nets are set out by a tending skiff and then monitored by the skiff and/or shore-based observers (see amendment request below). When one or more otters become entangled in the net, the skiff returns and extracts the otter(s), transferring them to capture boxes for transport to the processing site. The deployment of nets is made under due consideration of predicted weather conditions: nets will not be set during periods of weather or sea state that may preclude their tending. Unlike in Alaska, tangle nets are very rarely be used in California, and only under circumstances where their use will (in the best judgment of the permit holder) represent a significantly lower risk of disturbance to sea otters and/or other marine mammal species.

In an effort to minimize the chances of entanglements or by-catch of non-target species: 1) two shore-based observers with telescopes (instead of just one) will monitor a deployed net, with one observer continuously scanning the float line of the net in order to detect entanglements, and the second observer scanning the entire vicinity around the net for any marine mammal activity. In the event that any non-target marine mammals are detected in the area by that second observer, the tending skiff will be called in to either pull the net or else remain beside the net until the marine mammals have left the vicinity entirely; 2) at the time of net deployment, buoy-type floats will be attached to the float line at regular intervals (~10m apart) to increase the visibility of the float line and thus the likelihood that a shore-based observer with a telescope who was scanning that float line would be able to detect if even a small section of the net became pulled under water, signaling a possible entanglement. In such a case the tending skiff would be called in immediately to investigate (and release an entangled animal if that were the case).

<u>Dip Nets</u>

Dip-netting is a procedure where sea otters are dipped out of the water with a large fish-landing net. Open-water capture takes place from the bow of a small skiff, with one net handler and a vessel operator. This method is usually generally used to capture young animals. USGS personnel have been involved in the capture of >250 sea otters using dip-nets with no dip-net-related mortalities.

b. Methods of restraint and holding, including dimensions/type of holding container, if used;
The sea otters are transferred directly from the Wilson Trap, Tangle Net, or Dip Net, to a specially designed “otter box.” These boxes have been customized over many decades of sea otter capture and handling, and represent the best possible temporary holding container for sea otters. Box materials, dimensions, and accessories have been designed and approved by both sea otter biologists and sea otter veterinarians with decades of experience in handling and transporting wild sea otters.

The boxes are made of marine grade plywood with an epoxy coating to protect the otters and the box itself. The epoxy also creates a smooth surface on the interior, and makes the boxes easy to clean. Wood is a desirable material because it is strong and sturdy, but still soft enough that the most uncooperative otters can chew it without damaging their teeth. The interior dimensions of the boxes are 36”L x 17”W x 22”H, providing more than enough room for an adult male sea otter, or a female and large pup. The box features a sliding plywood lid. By design, the walls and lid create a dark interior, which is believed by veterinarians and animal care experts, to have a calming effect on the animals inside. Our decades of field experience with these boxes has shown that the otters appear to be very calm once inside the box.

All 4 sides, and the bottom panel of the box feature 5/8” holes drilled at multiple levels for adequate ventilation. These holes serve another purpose though. The box may be floated in the ocean, alongside the boat, at any time. The holes allow water to enter the box, so that the otter can float inside the box. The cold seawater helps the otter thermoregulate, and helps to prevent any overheating that might potentially occur as a physiological response to the capture process.

Inside the box, a “false bottom” is installed. This is a PVC grate that allows refuse or materials such as feces to pass through the grate and exit via the bottom of the box, eliminating any chance of the material fouling the otter’s fur. This keeps the interior of the box clean and tidy. Boxes also have canine “chew toys” (the kind you get at your local pet store) installed for the otter that like to chew. Chewing on a chew toy decreases the likelihood of the otters chewing on the wood box, while also giving them a distraction and enrichment experience while inside the box.

When otters need to be physically restrained (e.g. when being injective with the sedative) the procedure is done so in the safety of the otter box. A “stuff sack,” which is a very soft cushion similar to a pillow but covered with a tough cordura exterior, is used to gently block the otter’s head and shoulders while the vet administers the injection into the hindquarters. The process only takes a few seconds, and the otter usually uses the stuff sack as a chew toy.

c. The holding time required prior to transport or release of the animal;
Captured individuals will be transported from the capture location to the handling location in holding boxes that provide adequate ventilation. Ice or cold water will be provided as needed to keep the animals cool. Transport time will be kept to a minimum by co-locating capture vessels and handling/processing platforms. All animals will be released at or as near to their location of capture as is possible. Efforts will be made to process and release sea otters within 2 hrs of capture.

d. Number and roles of personnel participating in the captures;
The number of personnel involved in sea otter captures in California varies greatly, depending on the daily capture effort and/or the total duration of the capture event. However, it is not uncommon for the total number of personnel to number between 20-30 individuals. Roles are as follows:

Diver: 2 per boat, if multiple boats are used, there could be 4 or 6 divers working in teams of 2. The divers locate the target otters and perform the capture. They secure the otter in box, take local samples (water) and data (GPS, time, etc.), and transport the captured otter to the veterinary team on shore. This could involve dropping the otter off at the Monterey Bay Aquarium davit or a hoist on a pier, or transferring the otter shore via a beach-loading by inflatable boat, or transferring the otter to a larger vessel where the vet crew is operating. Depending on workload, the divers may also assist in animal processing and tagging. Diver's typically perform the releases of the otters as well.

Boat Operator: Assist with all the same duties as the divers, except the actual diving. Must be experienced otter spotter and skilled boat operator. Provides directions to the divers during the "capture run." Drives the boat and ensures the safety of the animals and the crew.

Boat Tender/Deckhand: Assist the Boat Operator in all tasks requiring assistance. Help secure and transport otters. Performs necessary duties of deckhand, including prepping and stowing gear, and assisting divers in and out of the water.

Shore Spotter: Usually in a team of 2, stationed on shore with binoculars and high-powered spotting scopes. Shore spotters are usually the ones that first locate the target otter, often using VHF radio telemetry (in the case of recaptures). Shore spotters relay location information and directions to boat crews and divers. During the capture run, shore spotters are able to assist the boat operator and tender by being and extra set of eyes (with a spotting scope). They can alert the boat crew or dive team to any changes in the status of the target otter, or if any hazards present themselves. The shore spotters also diligently monitor tangle nets, on the rare occasion that they are deployed.

Shore Team Coordinator: Orchestrates and oversees all shore-based operations from the time that the otters come ashore, to the time it is released or given back to the boat crews.

Veterinarian: Ultimately responsible for the well-being of the sea otters. Any judgement calls related to the health or safety of the animals are made by the vet in charge. The vet team performs surgeries, administers drugs, monitors anesthetized otters, and performs all examinations. Any data collected or procedures done on an otter once it reaches the vet team is supervised by the veterinarian.

Vet Tech: Assists the veterinarian and any and all duties required. May take samples/swabs from sea otters.

Blood Tech: Assists veterinarian and vet tech. Primarily responsible for obtaining, processing, and storing blood samples taken from the sea otters.

Data Tech: Responsible for recording a host of biological, morphological, and physiological data on every animal that is processed. Some examples of data collected: length, weight, tail length, paw width, age estimate, tooth condition, overall body condition, dental map of entire mouth, photos of mouth/teeth, baculum length, amount drugs or medication administered, reactions of animal (if any), details and timing of all procedures, etc.

e. Duration of restraint/holding from capture to release; and

As stated in (c) above, every effort is made to not exceed 2 hrs from time of capture to time of release. The otters are not physically restrained for this entire time. Most of the time is spent in the safety and relative comfort of the otter box, or anesthetized.

f. The number of non-target individual animals of the target species that will be incidentally harassed during capture activities, and precautions you will take to minimize incidental harassment of non-target animals;

During the most recent 5-year period the average number of sea otters incidentally harassed during capture activities was 54 per year (with a high of 93 in 2016). We expect the number to not be above 100 in any year. The majority of these incidental harassment cases occur during diving captures using Wilson traps and are almost always due to the habit of sea otters resting in groups or rafts. When capturing target otters in a raft, nearby otters may be disturbed. We attempt to minimize the disturbance or incidental harassment of non-target otters. The rebreather diver techniques described previously are the best way to minimize incidental harassment because the divers remain undetected for the entire dive, until the moment of capture. Our captures are most successful when we are completely undetected, so minimizing incidental harassment is inherent to the success of our work. When possible, we avoid targeting an animal when it's in a very large group of otters. The odds of successful capture decrease when the target is resting in a large group. Sometimes this cannot be avoided, however, most capture attempts are on solo animals, animals in pairs, or otherwise small rafts.

g. If capturing females with calves/pups/cubs, describe:

Sea otter females and pups generally rest together, with the pup either on top of the mother, or alongside the mother, often in contact with one another. Since our studies often aim to answer questions pertaining to demography, population biology, and survival, we don't explicitly avoid capturing mothers and pups, as this would introduce a substantial bias. However, we also don't specifically target mothers and pups. Also, females may be captured without a pup, but recaptured later on, with a pup. In general, we will avoid capturing a female with a newborn pup because of the small size of the pup. However, it is not always possible to see the small pup prior to a capture, and even if the pup is observed, it can be very difficult to determine age of the pup under difficult viewing or ocean conditions. As a result we are requesting the ability to capture all age classes or sea otters, but with the caveat that in situations where a newborn pup is easily visible, we will likely not attempt to capture that mother-pup pair. When capturing mothers and pups, they will either be (a) captured together in the same Wilson Trap or (b) be captured simultaneously in 2 different Wilson Traps, depending on how far apart the mother and pup are from one another. It is possible that, if a diver made an error or had an equipment/trap malfunction, a female may be captured without her pup, or a pup without it's mother. Although such an occurrence is rare, it has happened in the past. In such a situation, the captured animal (either mother or pup) is immediately released from the Wilson Trap, allowing them to reunite with each other. We have never had an issue with the mother and pup not reuniting on their own in a situation such as this.

i. How calves/pup/cubs will be held;

Immediately after capture, the mother and pup will be transferred to a holding box, like all captured otters. In general, the mother and pup are placed in the same holding box. However, certain instances may dictate that holding the mother and pup in separate boxes would be the most prudent course of action. For example, if the pup is quite small and the mother is not showing clear maternal behavior towards the pup, it might be safer to keep the pup in its own box, to prevent any possibility of incidental injury to the pup. At the other end of the spectrum, sometimes very large pups are as big as the mother. In this case, the mom and pup might be placed into separate holding boxes so that both otters can have sufficient space. Mothers and pups, regardless of age or pup size, are always released together to reduce the chance of separation.

ii. Which procedures will be conducted on them;

Females with pup may be subjected to all the normal veterinary procedures that any captured sea otter would normally be subjected to. This includes surgery for the implantation of VHF radio transmitters. In addition, sterile oxytocin (20 units/ml) may be injected intramuscularly to facilitate milk letdown in lactating females. Oxytocin, a hormone produced by the hypothalamus stimulates contraction of the smooth muscle of the mammary glands to release milk. We will only attempt to collect milk samples from females with dependent pups, no pregnant females or females without pups will be given oxytocin.

In general, the size of the pup dictates what samples, tags, or procedures are performed on the pup. The pup must weigh at least 20 lbs to qualify for and instrument implantation. Additionally, only pups greater 11 lbs will be flipper tagged. Pups weighing less than 6 lbs will not be PIT-tagged. Pups of all sizes may have morphometric data (e.g. length, weight) and demographic data (e.g. sex) collected.

iii. The duration of time the pair will be separated; and

Given that our estimated time from capture to release is 2 hrs, it's fair to say that the max time that a mother and pup would be separated is for this entire 2hr duration. In practice, the timing is much shorter, since the mother and pup usually share a holding box. If the mother is anesthetized for surgery, the pup will only be separated from the mom during the surgical procedure. This is typically <1 hr.

iv. Procedures used to reunite the pair, and if they do not reunite, explain the disposition of the calf/pup/cub.

We take all the necessary precautions to ensure that a separation of mother and pup does not occur. In fact, due to our precautions and the strong mothering instinct of female sea otters, a separation would be considered an extremely rare event. Therefore, reuniting a mother-pup pair is something that is almost never required in our work. As one of our precautions, we observe the behavior of the mother and pup together, in the holding box, to make sure their behavior is still indicative of a bonded pair (e.g. mother holding or grooming pup) before releasing them. We will also employ a "soft release" technique with moms and smaller pups. This method involves submerging the box on its side, about halfway in the water at the side of the boat, then slowly opening the door of the box. The otters will usually calmly swim out of the box.

However, in the extremely unlikely event of a separation, this would probably occur by virtue of the mother immediately leaving the holding box upon release, and leaving the pup behind in the box. This is only a concern with a small pup since larger pups are capable of swimming on their own and catching up to their mother. If a small pup is left behind in the box, the persons conducting the release will immediately remove the pup from the box and place it in the water to float. Releases are always done with the boat placed upwind so that the mother can smell her pup if she initially leaves without it. This will aid her in relocating her pup when she inevitably returns to look for it. In an extreme situation where the mother doesn't immediately return for the pup, the pup is held high in the air so that the sound of the pup's call can travel a greater distance, enticing the mother to return and retrieve her pup. If this still does not work, the pup will be left at the site of release, and the boat will back away. Our shore spotters will monitor the pup through a high-powered spotting scope to see if the mother returns to claim the pup. Should these attempts fail and the mother does not return, the pup will be rescued by the boat crew, and brought back into veterinary team. At the discretion of the lead veterinarian, if it is deemed that the pup has truly been abandoned, the pup may be raised in captivity at the Monterey Bay Aquarium as part of their surrogacy program, and could be released back into the wild once mature. We have never had to resort to this final step in many hundreds of wild sea otter captures.

h. A description of the use of drugs during capture, including:

i. Name of each drug/chemical used, its dosage rate (ml/kg), method of administration (IV, IM, SQ, topical and whether remotely-deployed IM), and purpose of the drug;

Chemical Immobilization / Anesthesia:

Approved personnel will immobilize sea otters following slightly modified procedures to those described in Monson et al. 2001, Chemical anesthesia of northern sea otters (Enhydra lutris): results from past field studies. In this paper, the benzodiazepine, diazepam, is one of the induction agents. Diazepam is well known for its inconsistent and unpredictable absorption when administered intramuscularly. An aqueous solution of a closely related drug, midazolam, is substituted milligram for milligram. As a result, expression of the effects of fentanyl, muscle rigidity and potential seizures is prevented.

Captured sea otters will be anesthetized in sliding-lid holding boxes using a combination of fentanyl citrate and midazolam hydrochloride (F/M) and reversed with naltrexone hydrochloride (N). This combination has been used successfully for the immobilization of over 1500 sea otters of both sexes, all age classes, and in varying states of physiological and/or pathological condition. There have been no anesthetic-related mortalities associated with this immobilization protocol in field settings to date. Fentanyl/Midazolam produces smooth inductions with little or no muscle tremors or convulsions while Naltrexone provides rapid, complete reversal of the opiate, fentanyl with no risk of re-induction. The holding boxes prevent premature escape of sedated animals while providing the captured otter a calm, quiet space. The observational access provided by these capture boxes facilitate close monitoring of sea otters as induction proceeds, as well as assurance that complete reversal, including return to normal body temperature, has occurred prior to release.

Intramuscular injections of fentanyl and midazolam are administered separately with different syringes at dose rates adjusted to the purpose of handling. Darting is not used because otters are usually in the water and the risks of drowning or ‘struck and loss’ are too great. We use target dose rates of 0.33 mg/kg of fentanyl and 0.11 mg/kg of midazolam for surgical procedures, and 0.22 mg/kg fentanyl and 0.07 mg/kg of midazolam for non-surgical, biological sampling procedures as recommended by Monson et al. (2001). If anesthesia is not complete after approximately 15 minutes, additional fentanyl may be given. If 2-times the initial fentanyl dose is incrementally reached, and sedation is still not complete, the antagonist is given and the animal released without further handling (this is rarely observed). In the event of excessive tremors or convulsions, additional intravenous midazolam may be administered. Inhalant agents, such as isoflurane or sevoflurane, may be used as needed should anesthetic depth be deemed inadequate by the attending veterinarian. Also, based on the best judgment of the attending veterinarian, local anesthetics such as bupivacaine may be applied when potentially painful procedures are considered in the case of animals that are immobilized with lower does or when anesthetic depth be deemed inadequate.

The reversal agent Naltrexone is administered intramuscularly, at a dose equal to 2-5 times the fentanyl dose, immediately following handling. In addition, sterile oxytocin (20 units/ml) may be injected intramuscularly to facilitate milk letdown in lactating females. Oxytocin, a hormone produced by the hypothalamus stimulates contraction of the smooth muscle of the mammary glands to release milk. We will only attempt to collect milk samples from females with dependent pups, no pregnant females or females without pups will be given oxytocin.

ii. Duration of drug and required holding time;

There are essentially two different doses of fentanyl/midazolam that are utilized. The lower dose is used for immobilization/restraint and provides approximately 60-90 minutes of sedation time. The higher dose level is the one utilized as an anesthetic dose and provides both immobilization and analgesia. The former will last for approximately 60 minutes with an additional 60 minutes of “restraint time” similar to that encountered at lower dosages.

There is an 8-12 minute lag time between the intramuscular administration of the drugs and effect. Both drugs have a reversal agent, however, typically only the fentanyl is reversed. Naltrexone is a direct antagonist requiring approximately 1-4 minutes to reverse the effects of fentanyl. It is metabolized more slowly than fentanyl, therefore re-sedation is not a problem. There is no post-reversal holding period required. Once animals are reversed, they are capable of being returned to the water and begin swimming immediately and foraging occurs shortly thereafter.

iii. The names of the personnel who would administer the drugs;

Michael Murray (DVM), Christine Fiorello (DVM), Nancy Anderson (DVM), Lesanna Lahner (DVM), Raymond Wack (DVM), Heather Harris (DVM), Christine Kreuder-Johnson (DVM), Cara Field (DVM), Shawn Johnson (DVM), Claire Simeone (DVM), and Dave Casper (DVM).

iv. Provisions to minimize adverse reaction(s), including the use of appropriate drug reversals;

Drug doses are adjusted based on the physical appearance of the otter, information obtained by interviewing the capture team, and the anticipated level of chemical immobilization required. The lowest dose possible is administer. Reversal agents for fentanyl and midazolam, naltrexone and flumazenil, respectively, are always on hand in case of emergency. The naltrexone is always drawn into a syringe and ready for administration before induction agents are administered. Traditional emergency preparedness is practiced, with emergency drugs, endotracheal intubation equipment/supplies, and provision for oxygen administration on hand. In case of instability which cannot be readily managed, reversal agents are administered either intravenously or intramuscularly depending upon the situation.

v. Procedures to be used to minimize the chance that drugged animals will escape or enter the water prior to complete immobilization; and

Darting is not used because otters are usually in the water and the risks of drowning or 'struck and loss' are too great. Animals are drugged in the confines of a holding box (previously described in this permit application). As such, the otters are not near any water and cannot escape.

vi. Measures to be taken to ensure that the animal is fully recovered prior to release.

Naltrexone is the reversal drug that is administered. Naltrexone has a rapid onset and the initial "first response" time is typically noted within one minute. Monitoring by an experienced team member continues until reversal is complete and the animal is deemed releasable by the attending veterinarian. Monitoring and evaluation of the reversal is performed in the confines of the holding box. The otter is only returned to the boats/release crew once the vet has determined that it is fully reversed and ready for release. Typically, at least 10 additional minutes will pass from the time of transfer to the release crew to the actual release, since travel back to the site of capture is often required.

i. What emergency procedures would be employed (e.g., drugs, bagging, CPR, etc.) in the event that an animal's condition starts deteriorating during capture activities?

In case of emergency, traditional medical response protocols will be followed. If the otter has received immobilization drugs, their effects will be reversed with the appropriate antagonists, typically naltrexone and flumazenil. Additional emergency procedures, if needed, will follow the ABCD's of emergency medicine. A: establish airway. In sea otters this will involve the provision of supplemental oxygen. The otter may require tracheal intubation and intermittent positive pressure ventilation. B: breathing. Respiratory rates, effort, and effectiveness will be monitored. If need be, assisted ventilation with pure oxygen or ambient air will be provided. Pulse oximetry and/or blood gas monitoring will be done to ensure efficacy of respiration. C: circulatory. In cases of actual, suspected, or impending circulatory collapse, intravenous catheterization of the external jugular vein may be necessary. Supplemental fluids can then be administered to provide circulatory support. D: drugs. A spectrum of emergency drugs will be on hand in a well-stocked emergency kit. These drugs will be administered based upon the data obtained and interpreted by the attending veterinarian.

PART III

17. Explain how the proposed research meets the MMPA definition of "bona fide research," i.e., scientific research on marine mammals, the results of which: (A) are likely to be accepted for publication in a referenced scientific journal; (B) are likely to contribute to the basic knowledge of marine mammal biology or ecology; or (C) are likely to identify, evaluate, or resolve conservation problems.

The research conducted under this permit will result in creation of manuscripts likely to be accepted in scholarly/peer-reviewed journals, based on our past research activities (see citation list of peer-reviewed publications based on research conducted under prior versions of this permit). This research will also be beneficial to evaluation and remediation of anthropogenic factors that may contribute to sea otter mortality and thus prevent recovery of this stock. Additionally, data and samples collected under this permit will add to the basic knowledge of sea otter biology and ecology, allowing better informed management and conservation decisions.

18. Provide a detailed description of the proposed project. You may attach a formal research proposal, provided it includes all the requested information, including:

a. Objectives and hypotheses and associated methodology;

b. Background information discussing relevant published literature on the subject of your proposal, with citations;

c. An explanation of how this study is different from, builds upon, or duplicates past research;

d. An explanation of how you determined your sample size/take numbers (e.g., based on previous encounter rates or abundance estimates for the study area). If appropriate for your study, include a power analysis or other sample size estimation to show whether the sample size is sufficient to provide statistically significant or otherwise robust results appropriate for your study;

e. If proposing novel procedures, include a discussion on results from pilot studies or studies on other species, if available; and
f. Disposition of animals or remaining specimen material once your project is complete.

Pleased see the enclosed documents for the proposals for 3 studies that are currently in progress.

In brief, the Monterey NSF Predator Diversity Study is investigating the impact of a sudden loss of a meso-predator (sea stars) on kelp forest community composition, and the the ability of sea otters to mitigate the loss of other predators in the system through behavioral plasticity. The study has the potential to redefine the role of sea otters in kelp forest communities. The results may elucidate the mechanism by which otters "control" urchins/grazers, and will demonstrate why simply having a healthy sea otter population may not be the only requirement for healthy kelp forest ecosystems in California.

The on-going San Nicolas Island Sea Otter Population Monitoring work is a continuation of a multi-decadal survey that monitors the status and growth or decline of a translocated population of sea otters at San Nicolas Island. The US Navy is funding additional monitoring work that involves diet and behavioral observations. The project utilizes a tiered approach, based on the findings of our research. If survey numbers drop below a critical threshold, or if sea otter deaths as a result of US Navy activities are observed, the project would advance to the next tier, and may eventually require the capture, tagging, and intensive monitoring of sea otters at San Nicolas Island.

The Tagging Technology project is described elsewhere in this application, but this joint NASA-USGS venture aims to utilize state-of-the-art technology to finally incorporate GPS data in a sea otter tag, allowing for more accurate and frequent resights of sea otters with much less effort/personnel. Moreover, the tags are being designed to work in a mesh-network, where individual otters will resight each other, via tags that communicate with one another, and offload their data to base stations whenever they are in range. This tagging technology is cutting edge, and will greatly advance our knowledge of sea otter ecology, behavior, movements, and interactions. It will also present a less invasive alternative to studying sea otter behavior.

19. Provide the expected research schedule (clearly specify the proposed start date and end date of your research or field season(s) and overall duration of the project). Include the months of the year and frequency of fieldwork/sampling (e.g., number of times per year). If your research extends beyond five years, or is a continuation of previously authorized research, give information about when the research began and when you expect it to end.

Our research program has been essentially continuous since 1998, and is part of a long-term monitoring and research program mandated and supported by the Federal agency responsible for management of this species. Research is ongoing at sites throughout the sea otter's range in coastal California (see research proposals above), and these (or similar) studies are anticipated to continue throughout the 5-year period covered by the permit. Because of the broad, comparative nature of our research, and the need to obtain representative data from throughout the range (and over all seasons and across years) on all population parameters, sampling may occur at any location within the current range of southern sea otters (see attached map, Figure 2) and at any time of year within the time period covered by the permit.

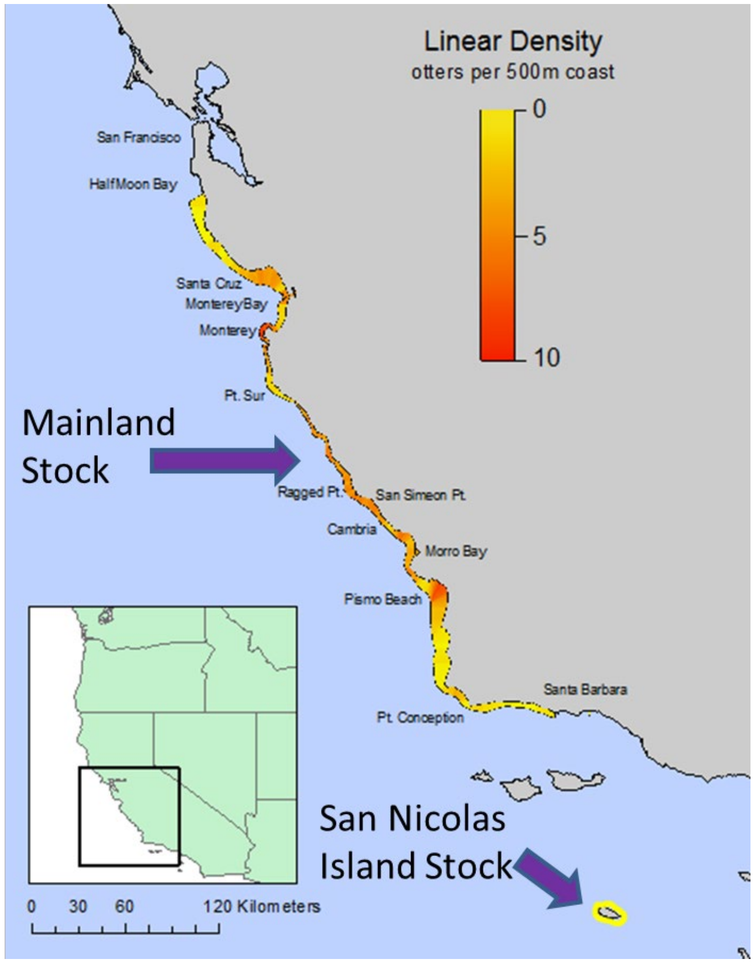


Figure 2. *Range of the Southern sea otter population showing the separation of the two stocks. Sea otter distribution shown as colored band along the coast, with warmer colors corresponding to higher sea otter densities.*

20. Indicate which research procedures/activities you will be conducting that will or might result in **TAKE or HARASSMENT of TARGET species**, and describe each activity in detail, including the information indicated in a-i, below.

Take or harassment of targeted sea otters will occur when sea otters are captured by one of three methods (described in detail in section 12b): tangle nets, underwater diver-held traps (Wilson traps), or hand-held dip nets. All methods are routinely used throughout the range of the sea otter population (U.S., Russia, and Canada). Recapture of individuals will be by underwater diver-held Wilson traps.

Because of the broad, comparative nature of our research, and the need to obtain representative data from throughout the range (and over all seasons and across years) on all population parameters, sampling may occur at any location within the current range of southern sea otters (see attached map, Figure 2) and at any time of year within the time period covered by the permit.

See attached USGS WERC Santa Cruz Field Station IACUC-approved SOP: Sea Otter Capture, Chemical Immobilization, Routine Sampling, and Routine Surgery for more details on capture and sampling methods.

a. Administration of drugs (including emergency drugs and prophylactic antibiotic use) or other substances (e.g., stable isotopes); include i-vii, below, in your activity description:

i. Name of each drug/chemical used, its dosage rate (ml/kg), method of administration (IV, IM, SQ, topical and whether remotely-deployed IM), and purpose of the drug;

Approved personnel will immobilize sea otters following slightly modified procedures to those described in Monson et al. 2001, Chemical anesthesia of northern sea otters (Enhydra lutris): results from past field studies. In this paper, the benzodiazepine, diazepam, is one of the induction agents. Diazepam is well known for its inconsistent and unpredictable absorption when administered intramuscularly. An aqueous solution of a closely related drug, midazolam, is substituted milligram for milligram. As a result, expression of the effects of fentanyl, muscle rigidity and potential seizures is prevented.

Captured sea otters will be anesthetized in sliding-lid holding boxes using a combination of fentanyl citrate and midazolam hydrochloride (F/M) and reversed with naltrexone hydrochloride (N). This combination has been used successfully for the immobilization of over 1500 sea otters of both sexes, all age classes, and in varying states of physiological and/or pathological condition. There have been no anesthetic-related mortalities associated with this immobilization protocol in field settings to date. Fentanyl/Midazolam produces smooth inductions with little or no muscle tremors or convulsions while Naltrexone provides rapid, complete reversal of the opiate, fentanyl with no risk of re-induction. The holding boxes prevent premature escape of sedated animals while providing the captured otter a calm, quiet space. The observational access provided by these capture boxes facilitate close monitoring of sea otters as induction proceeds, as well as assurance that complete reversal, including return to normal body temperature, has occurred prior to release.

Intramuscular injections of fentanyl and midazolam are administered separately with different syringes at dose rates adjusted to the purpose of handling. Darting is not used because otters are usually in the water and the risks of drowning or 'struck and loss' are too great. We use target dose rates of 0.33 mg/kg of fentanyl and 0.11 mg/kg of midazolam for surgical procedures, and 0.22 mg/kg fentanyl and 0.07 mg/kg of midazolam for non-surgical, biological sampling procedures as recommended by Monson et al. (2001). If anesthesia is not complete after approximately 15 minutes, additional fentanyl may be given. If 2-times the initial fentanyl dose is incrementally reached, and sedation is still not complete, the antagonist is given and the animal released without further handling (this is rarely observed). In the event of excessive tremors or convulsions, additional intravenous midazolam may be administered. Inhalant agents, such as isoflurane or sevoflurane, may be used as needed should anesthetic depth be deemed inadequate by the attending veterinarian. Also, based on the best judgment of the attending veterinarian, local anesthetics such as bupivacaine may be applied when potentially painful procedures are considered in the case of animals that are immobilized with lower does or when anesthetic depth be deemed inadequate.

The reversal agent Naltrexone is administered intramuscularly, at a dose equal to 2-5 times the fentanyl dose, immediately following handling. In addition, sterile oxytocin (20 units/ml) may be injected intramuscularly to facilitate milk letdown in lactating females. Oxytocin, a hormone produced by the hypothalamus stimulates contraction of the smooth muscle of the mammary glands to release milk. We will only attempt to collect milk samples from females with dependent pups, no pregnant females or females without pups will be given oxytocin.

ii. Duration of drug and required holding time;

There are essentially two different doses of fentanyl/midazolam that are utilized. The lower dose is used for immobilization/restraint and provides approximately 60-90 minutes of sedation time. The higher dose level is the one utilized as an anesthetic dose and provides both immobilization and analgesia. The former will last for approximately 60 minutes with an additional 60 minutes of "restraint time" similar to that encountered at lower dosages.

There is an 8-12 minute lag time between the intramuscular administration of the drugs and effect. Both drugs have a reversal agent, however, typically only the fentanyl is reversed. Naltrexone is a direct antagonist requiring approximately 1-4 minutes to reverse the effects of fentanyl. It is metabolized more slowly than fentanyl, therefore re-sedation is not a problem. There is no post-reversal holding period required. Once animals are reversed, they are capable of being returned to the water and begin swimming immediately and foraging occurs shortly thereafter.

iii. The names of the personnel who would administer the drugs;

Michael Murray (DVM), Christine Fiorello (DVM), Nancy Anderson (DVM), Lesanna Lahner (DVM), Raymond Wack (DVM), Heather Harris (DVM), Christine Kreuder-Johnson (DVM), Cara Field (DVM), Shawn Johnson (DVM), Claire Simeone (DVM), and Dave Casper (DVM).

iv. A description of specific State requirements regarding who (e.g., attending veterinarians, vet technicians, researchers) may handle and administer certain drugs;

Only attending veterinarians will administer and handle the drugs described here

v. Provisions to minimize adverse reaction(s), including the use of appropriate drug reversals;

Drug doses are adjusted based on the physical appearance of the otter, information obtained by interviewing the capture team, and the anticipated level of chemical immobilization required. The lowest dose possible is administer. Reversal agents for fentanyl and midazolam, naltrexone and flumazenil, respectively, are always on hand in case of emergency. The naltrexone is always drawn into a syringe and ready for administration before induction agents are administered. Traditional emergency preparedness is practiced, with emergency drugs, endotracheal intubation equipment/supplies, and provision for oxygen administration on hand. In case of instability which cannot be readily managed, reversal agents are administered either intravenously or intramuscularly depending upon the situation.

vi. Procedures to be used to minimize the chance that drugged animals will escape prior to complete immobilization; and

Darting is not used because otters are usually in the water and the risks of drowning or 'struck and loss' are too great. Animals are drugged in the confines of a holding box (previously described in this permit application). As such, the otters are not near any water and cannot escape.

vii. Measures to be taken to ensure that the animal is fully recovered prior to release.

Naltrexone is the reversal drug that is administered. Naltrexone has a rapid onset and the initial "first response" time is typically noted within one minute. Monitoring by an experienced team member continues until reversal is complete and the animal is deemed releasable by the attending veterinarian. Monitoring and evaluation of the reversal is performed in the confines of the holding box. The otter is only returned to the boats/release crew once the vet has determined that it is fully reversed and ready for release. Typically, at least 10 additional minutes will pass from the time of transfer to the release crew to the actual release, since travel back to the site of capture is often required.

b. Aerial and vessel surveys (manned); include i-v, below, in your activity description:

i. Type of survey craft and vessel;
ii. Type of survey (e.g., line transect, photogrammetry);
iii. Number of surveys per year;
iv. Minimum and maximum altitude/approach distance; and
v. Duration spent with group or individual per day.

We are not requesting any takes as part of aerial or vessel surveys.

c. Aerial surveys using unmanned aircraft systems (UAS); include i-xii, below, in your activity description:

i. Dimensions, mass, and battery life of UAS;
ii. Will the UAS ever be beyond the line of sight?
iii. Does the device have an auto-return feature should the device fail?
iv. Ground control station description (what it is, where it will be located, e.g., on shore or on vessel, number of stations, and how close the station will be to animals);
v. Spotter roles (e.g., one spotter monitoring the UAS, another for monitoring the ground control station);
vi. Do you have the appropriate FAA permits/authorizations (including pilot licenses)?
vii. Type of survey (e.g., line transect, photogrammetry);
viii. Number of surveys per year;
ix. Minimum and maximum altitude/approach distance;
x. Duration spent with group or individual per day;
xi. The names of the personnel who will pilot the aircraft, and
xii. Mitigation measures you will use to minimize disturbance including specific measures you will use to avoid separating female-calf/pup/cub pairs, and measures to ensure the UAS will not collide or crash into any of the animals.

At this time, we are not requesting takes as part of UAS surveys. We hope to use UAS in the future for a variety of applications, however, we are currently not using UAS at present. If the need arises in the future, we will submit a request for an amendment to our permit.

d. Capture and restraint; if you will be capturing animals, ensure that you have completed question 10, above.

Question 10 has been completed.

e. Instrumentation, Marking, and Tagging (MTI); include i-x, below, in your activity description:
i. The type of MTI (including dimensions and mass);

Flipper Tags
Generally all animals captured > 11 lbs will be visually tagged to prevent repeated sampling of the same individuals. Temple tags, used on the hind flippers, are 45 x 14 x 2 mm, and weigh ~7g. Because long-term tag retention rates are <100% (Ames et al. 1982, 1983) each sea otter may also be marked with a coded, passive transponder chip, implanted subcutaneously in the inner thigh. When flipper-tagging, holes are punched using a sterile leather punch (hole diameter <5mm). Flipper tags have been used extensively in sea otter research and rehabilitation effort without any observed deleterious effects.

In addition, we request the ability to use newer electronic “smart” flipper tags in place of 1 or more of the traditional Temple Tags described above. The smart flipper tags will be of comparable size any weight, but are still being developed and tested. These smart tags will have GPS capability allowing them to “talk” to other tags or base stations when in range. They are solar-powered and may include other additional sensors like an accelerometer, wet/dry switch, pressure sensor, etc. These tags are being developed in a collaboration between USGS and NASA. Concurrent to tag development, different materials and form factors are being tested on captive sea otters at the Monterey Bay Aquarium. These smart tags will be capable of collecting geo-location data and conducting otter-shore communications, and we anticipate that eventually they will replace the implantable VHF transmitters as a less-invasive, primary means of sea otter tracking/monitoring. With the addition of a pressure sensory, these tags may even have the ability to eventually replace TDRs, which could eliminate our need to surgically implant instruments in sea otters at a future date. The form-factor and attachment method are similar to the temple tags, and these smart tags would only be deployed on wild otters once enough testing has been conducted with captive otters to ensure that there is no negative response to these tags.

PIT Tags
Implantation of “passive integrated transponders”, or PIT tags, may be done to facilitate identification in the event of external tag loss. PIT tags have been safely used in multiple species of all sizes, including sea otters, without deleterious effects to survival. 125 MHz tags, approximately 13 x 2mm, will be injected into the left inguinal area using a 12 gauge needle and syringe. Tag, needle, and syringe are gas-sterilized together in a package or come pre-sterilized from the manufacturer (Biomark, Boise, ID). PIT tags are encased in biocompatible glass which protects the electronics while preventing adverse effects to the animal. All captured otters will be scanned prior to initiation of sampling/external tagging for identification and to access prior capture history.

VHF Radio Transmitters
For some aspects of our research, use of electronic signaling tags is necessary. VHF radio transmitters (80 x 22 x 50mm, ~160g, Advanced Telemetry Systems, Isanti, MN) are standard instruments that are currently surgically implanted in sea otters. Radios are potted in a waterproof electrical resin and coated with a USP Class VI material (United States Pharmacopeia, Class VI requires the most stringent testing). Instruments are gas-sterilized

and sealed in surgical steri-peal pouches for storage until used. This procedure has been successfully completed on several hundred sea otters in Alaska and California with very low rates of mortality (< 0.2%).

ii. The maximum number and total mass of MTIs to be attached to/implanted in an animal at a given time;

Each otter will be tagged with unique color/number coded polyethylene “Temple Tags” (livestock ear tags, Temple, TX) in their hind flippers (typically 2 tags per otter [1 per flipper], no more than 4 tags [2 on each flipper]). The minimum total mass of 2 flipper tags would be a combined 14g, with the maximum (4 tags) equaling approximately 28g.

A maximum of 1 VHF radio transmitter will be implanted (total mass ~160g).

iii. The maximum dart penetration depth if MTI is attached via darts;

Not applicable. We do not use darts.

iv. Methods and location of attachment, including minimum approach distance for remote MTI attachment;

Flipper Tags

Flipper tags are attached to the hind flippers in the space (webbing) between the flipper digits. A sterile leather punch (<5mm) is used to punch a hole in the webbing of the flipper, taking care to avoid blood vessels. The plastic or composite tag is threaded through the punched hole and secured with a screw. The screw is embedded within the tag, glued to ensure a stronger hold, and recessed/not exposed in any way. At the discretion of the DVM, two holes may be punched per flipper tag, if deemed appropriate for a more secure attachment. Typically one flipper tag will be applied to each flipper, but occasionally a 3rd or 4th flipper tag may be applied, if additional colors are needed for identification or if traditional Temple Tags are needed to accompany a new electronic flipper tag. No more than 2 flipper tags would be applied per flipper.

Surgical Implantation (VHF) Procedure

VHF transmitters are internally implanted, rather than being externally attached as in many marine mammal species, because 1) sea otters are unable to tolerate external attachments that might compromise their pelage (which is critical for thermoregulation), and 2) attached instruments similar to those used on pinnipeds would compromise their swimming and foraging abilities because of their small size. Furthermore, because of the nature of sea otter grooming activity, they are capable of reaching and removing (or destroying) most existing types of externally-attached tags.

Consistent with sound veterinary surgical practice, abdominal surgery, including implantation of VHF is done with aseptic technique. Modifications of traditional methods are necessary, however, in order to accommodate the need for immediate post-operative return to the wild and preservation of the integrity of the sea otter’s pelage due to its importance in thermoregulation. Rather than shaving the fur from the surgical site, the fur overlying the ventral midline is parted with a fine-toothed comb and held in place with a combination of water soluble, sterile surgical lubricating jelly and aqueous 10% solution of povidone-iodine.

Access into the abdominal cavity is through an appropriately sized (6-10 cm) incision through the linea alba. Individually sterilized VHF transmitters are then placed directly into the abdominal cavity. If deemed necessary by the surgeon a solution of diluted antibiotic may be infused into the body cavity prior to closure.

A multi-layer, typically consisting of 4 separate suture lines, linea alba, subcutanesous fat/muscle, subcuticular, and skin, closure is meticulously performed to assure a water-tight seal, as well as to mitigate the potential for dehiscence either due to technique or self-mutilation. A sterile, mono-filament suture which is minimally reactive, provides adequate longevity, yet is absorbed over time is used to close surgical incisions.

In addition to the process described above, additional safeguards are applied during instrument extraction/replacement surgeries. Since surgeries of this nature are more invasive with larger incisions, and greater duration, additional prophylactic measures are taken. In addition to the surgical drapes attached to the skin a secondary sterile draping system is utilized being affixed to either the subcutis or through a specialized sterile wound retractor.

A broad spectrum, extended duration antibiotic is administered in conjunction with surgery. Any significant pathology encountered intra-operatively will be investigated within the limits of the patient's wellbeing. A record of the surgical procedure and associated findings is completed following each procedure.

v. If surgeries for implantable tags are being conducted, specify who will be conducting them, where (in the field or in a facility), and if antibiotic prophylactics will be administered;

Per the previous description in (iv), surgeries to implant VHF radio transmitters will be conducted by authorized veterinarians listed on this permit. The lead veterinarian (usually Dr. Mike Murray of the Monterey Bay Aquarium) supervises other vets and vet techs working under him. For captures in the vicinity of Monterey, surgeries and animal processing will be done in the state-of-the-art Animal Health Lab at the Monterey Bay Aquarium. For captures in more remote locales, surgeries may be conducted in an advanced mobile vet lab (provided by the California Department of Fish & Wildlife) or on a large research vessel in even more remote areas. Prophylactic broad spectrum, extended duration antibiotics will be administered in conjunction with surgery. Refer to (iv) above, the attached SOPs and the veterinary section of question 10 for more information on surgery and antibiotics.

vi. The maximum number of times an animal would be fitted with MTIs in a given year;

Because the flipper tags are made of plastic or some other similar soft material, they may occasionally be chewed off by the sea otters. This is by design, since the soft plastic will not harm the teeth of the otter. We request the ability to recapture an individual to replace flipper tags no more than 3 times per year, with a minimum of at least 3 months between captures of the same individual. There could be a need to collect additional blood or tissue samples, which can be done at the same time as the flipper tag replacement. We will make an attempt to recapture otters equipped with previously implanted time-depth recorders (TDRs) in order to retrieve/explant the TDR instrument so that the archival dive and temperature data can be downloaded. Recapture for TDR explant will take place whenever a sea otter is captured that has an existing TDR from a previous study/permit. We may also recapture an otter to replace the VHF radio if the battery begins to die. Typically, VHF radio batteries last approximately 3 years, for recapture for the purpose of implanting a new VHF radio (if deemed appropriate, for the continuation of the study), would occur once after 2-3 years. Replacement surgery would be performed no more than one time on any given animal.

vii. Will recapture be necessary (if so, how many times will animals be captured annually), would the instrument/tag have a release mechanism, or would the instrument/tag fall off?

Per the previous response (vi), recaptures are necessary for two main reasons. (1) to replace flipper tags that have been chewed off by otters and (2) to explant TDR instruments that were previously implanted under our earlier permits. Because the TDRs and VHF radios are surgically implanted, there is no release mechanism. A third reason, as described above, would be if it is deemed necessary to replace a dying VHF radio with a new radio. This would be a rare occurrence, and would happen only once after at least 2 years from the original radio implantation.

viii. Have the proposed MTIs been used previously on this species?

The Temple Tags, PIT tags, VHF transmitters, and TDRs have been used for many decades on hundreds (or in the case of PIT and flipper tags, thousands) of sea otters, with a very high success rate.

The "smart tag" flipper tags have not yet been deployed on wild sea otters, since they are a cutting-edge technology that is still in development. However, the form factor of these new smart flipper tags will be nearly identical to a Temple Tag, so we don't expect the otters to react to these tags any different than they would the Temple Tags. Regardless, the new tags are undergoing extensive testing on captive sea otters at the Monterey Bay Aquarium, to ensure that they have no adverse impacts on sea otters. Only once we are happy with the results on the captive sea otters, will we deploy this new tag on wild sea otters.

ix. What are the potential adverse effects and the means of monitoring new MTIs for adverse effects?

The only new MTI is the smart flipper tag. Because these tags haven't been used before, and because they are still being developed, it's impossible to know with 100% certainty what adverse effects they might have. However, because the size, weight, and form factor is nearly identical to the existing Temple Tags that have worked remarkably well for decades, we don't anticipate any adverse effects from these new smart flipper tags. As previously mentioned, the new tags are currently undergoing rigorous testing on captive sea otters at the Monterey Bay Aquarium to ensure that they have no adverse impact on the host otters. Once we are satisfied with captive testing, we will deploy the tags on wild sea otters. Given the nature of our research projects, we have observers visually locating the tagged otters multiple times a week (and sometimes daily), which gives us a mechanism for monitoring the well-being of the otters, and any potential adverse effects of the new tags, in real time. If an otter appears to be in severe distress as a result of the tag, we have the capability of deploying a team to capture the otter to help remedy the situation and/or get the otter the treatment it requires from qualified veterinary personnel. The nearshore habits of sea otters allows for a level of direct visual monitoring that is impossible with most other marine mammals.

x. What actions will be taken in the event that the MTI has a significant adverse impact on the animal(s), and what is the method of animal release from the MTI?

If a significant adverse impact is detected by our visual observers, a team of divers can be deployed to recapture the otter in question. Depending on the nature of the impact or distress, it may be remedied on site, or the otter may be brought in to qualified veterinary personnel for examination and/or treatment.

f. Intrusive sampling (e.g., blood, blubber, muscle, skin); include i-xiii below, in your activity description:

Each captured or sampled otter will be given a unique ID number. All specimens collected from an otter will be marked with that unique ID as well as sample type and date of collection. The following table (Table 1) provides details of the types and sizes of samples to be collected as well as storage details. Collection of these samples is standard and was previously permitted under MA672624.

Table 1. Listing of samples and their research uses collected from captured sea otters and/or beach-cast remains. Note that some samples may be collected from both live captured animals and carcasses, while some can only be collected from one or the other. All samples listed have been approved on our previous permit.

TABLE 1. Samples authorized for collection from captured sea otters or beachcast remains				
Sample Type	**Live/Carcass**	**Amount Collected**	**Use**	**Comments**
Blood	Live	5% blood volume (blood volume = 8% BW	Hematology, clinical chemistry, infectious disease monitoring, biomarkers, contaminants	Blood volume "lost" from animal to include collection, loss to hematoma, bleeding from tagging, and surgical bleeding
External swabs (integument, oral cavity, rectum, genital orifice	Live	No volume limitation	Infectious disease (bacterial, fungal, parasitic, viral), contaminants, genetics	
Saliva	Live	0.3 - 1.0 ml	Hormonal assays	
Feces	Live	No limit	Diet assessment, infectious disease (bacterial, fungal, parasitic, viral), contaminants, biotoxin, hormonal assay	From environment
	Live	< 100gm		Collected from rectum
Milk	Live	< 10 ml	Nutritional content, fatty acid analysis, contaminants	May require administration of oxytocin to cause release
Urine	Live	TBD by DVM	infectious disease, toxins, urinalysis, contaminants	Free catch or cystocentesis
Adipose tissue	Both	< 10 gm (live)	Fatty acids, contaminants	May require surgical intervention with appropriate consideration for anesthesia and surgical methodology.
		No limit (dead)		
External pathology (integument, oral cavity, genital orifice)	Both	TBD by DVM	Histopathology, genetics, etiopathogenetic investigation	May require surgical intervention with appropriate consideration for anesthesia and surgical methodology.
Liver biopsies	Both	< 2 gm (live)	Histopathology, toxicology, contaminants, genetics, chemical analysis (ie, Vit A analysis)	May require surgical intervention with appropriate consideration for anesthesia and surgical methodology.
		No limit (dead)		Collected at necropsy
Premolar tooth	Both	1	Cementum aging	First upper premolar, only
Skin plugs	Both	< 2 gm (live)	Genetics	Collected in association with flipper tagging in live animals
Vibrissae	Both	2	Stable isotope	
Baculum	Carcass	1	Morphometrics, stable/radio isotopes	
Tooth	Carcass	No limit (dead)	Cementum aging	
Skull	Carcass	1 or portions	Morphometrics, stable/radio isotopes	
Fur	Both	NMT 1 gm	Hormonal assays, toxins, contaminants	Collected by plucking as not to interfere with thermoregulation.

i. Will sampling be remote or under restraint?
The otters will be anesthetized during sampling.

ii. Will local anesthetics be administered?
A general anesthetic is used.

iii. Type of tissues sampled;

Blood, external swabs (integument, oral cavity, rectum, genital orifice), saliva, feces, milk, urine, adipose tissue, external pathology (integument, oral cavity, genital orifice), liver biopsies, premolar tooth, skin plugs, vibrissae, baculum, tooth, skull, fur

iv. Size or volume of sample (diameter and depth or total volume);

Blood: 5% blood volume (blood volume = 8% BW)
External Swabs: No volume limitation
Saliva: 0.3 - 1.0 ml
Feces: no limit when collected from environment; < 100gm when collected from rectum
Milk: < 10 ml
Urine: TBD by DVM
Adipose Tissue: < 10 gm (live otter); no limit for dead otter
External Pathology: TBD by DVM
Liver Biopsies: < 2 gm (live otter); no limit for dead otter
Premolar Tooth: 1
Skin Plugs: < 2 gm (live otter), collected in associated with flipper tagging the otter
Vibrissae: 2
Baculum: 1 (dead otter only)
Tooth: no limit (dead otter only)
Skull: 1 or portions of whole skull (dead otter only)
Fur: NMT 1 gm

v. Target sampling location on body;

Blood: Intravenous blood draw
External Swabs: Integument, oral cavity, rectum, genital orifice
Saliva: mouth/buccal cavity
Feces: rectum
Milk: teats/mammillary glands
Urine: genital orifice/bladder
Adipose Tissue: body cavity
External Pathology: integument, oral cavity, genital orifice)
Liver Biopsies: liver
Premolar Tooth: mouth/buccal cavity
Skin Plugs: flippers
Vibrissae: muzzle/snout
Baculum: genital region
Tooth: mouth/oral cavity
Skull: head
Fur: exterior/pelt/thoracic

vi. Maximum number of samples per animal per day and per year;

Blood: 5% blood volume (blood volume = 8% BW) per animal per day, max of twice per year
External Swabs: No volume limitation per day, max of twice per year
Saliva: 1.0 ml per day; 2.0ml per year
Feces: no limit when collected from environment; 100gm max per animal per day or 200gm max per animal per year when collected from rectum
Milk: 10 max ml per animal day; 20 ml max per animal per year
Urine: TBD by DVM
Adipose Tissue: 10 gm max per animal per day; 20 gm max per animal per year (live otter); no limit for dead otter
External Pathology: TBD by DVM
Liver Biopsies: 2 gm max per animal per day; 4 gm max per animal per year (live otter); no limit for dead otter
Premolar Tooth: 1 max per animal per day or per year

Skin Plugs: 2 gm max per animal per day; 4 gm max per animal per year (live otter)
Vibrissae: 2 max per animal per day; 4 max per animal per year
Baculum: 1 max ever (dead otter only)
Tooth: no max limit ever (dead otter only)
Skull: 1 or portions of whole skull (dead otter only)
Fur: NMT 1 gm per otter per day; NMT 2 gm per otter per year

vii. Sampling intervals (e.g., for serial blood or biopsy samples);

Samples taken at the time of recapture. As previously state, recaptures, and therefore sampling, will never occur more often than at 3-month intervals, though in practice, most recaptures are annual, or even less frequent.

viii. Collection method and equipment/materials used (e.g., dart fired from rifle, dart depth, sterilization/disinfection);

Refer to Table 1, above. Also, all samples are taken while the animal is “on the table” and anesthetized. The equipment and materials used are all standard medical/veterinary tools that would normally be used in a lab or surgery suite.

ix. If remote, what is the minimum approach distance?

N/A

x. If restrained, describe treatment of site of sample collection (e.g., cleansing, wound left open or closed);

Otters are anesthetized and most samples are minimally invasive (refer to Table 1). For samples that may draw blood (blood sample, premolar sample) the site may bleed and is treated with gauze in the same way you would treat a blood draw in a human.

xi. Number of attempts per animal per day (include total number of attempts needed for all work if requesting multiple procedures (e.g., remote tagging and biopsy) on same animal on the same day);

Because sampling is only done at the time of capture, this is only 1 attempt to collects the necessary samples for each capture/recapture.

xii. The names of the personnel who will conduct the sampling; and

Michael Murray (DVM), Christine Fiorello (DVM), Nancy Anderson (DVM), Lesanna Lahner (DVM), Raymond Wack (DVM), Heather Harris (DVM), Christine Kreuder-Johnson (DVM), Cara Field (DVM), Shawn Johnson (DVM), Claire Simeone (DVM), Dave Casper (DVM), Melissa Miller (DVM), Marissa Young, and Michelle Staedler.

xiii. Sample preservation and analysis.

Blood: Hematology, clinical chemistry, infectious disease monitoring, biomarkers, contaminants
External Swabs: Infectious disease (bacterial, fungal, parasitic, viral), contaminants, genetics
Saliva: Hormonal assays
Feces: Diet assessment, infectious disease (bacterial, fungal, parasitic, viral), contaminants, biotoxin, hormonal assay
Milk: Nutritional content, fatty acid analysis, contaminants
Urine: infectious disease, toxins, urinalysis, contaminants
Adipose Tissue: Fatty acids, contaminants
External Pathology: Histopathology, genetics, etiopathogenetic investigation
Liver Biopsies: Histopathology, toxicology, contaminants, genetics, chemical analysis (ie, Vit A analysis)
Premolar Tooth: Cementum aging
Skin Plugs: Genetics

Vibrissae: Stable Isotopes
Baculum: Morphometrics, stable/radio isotopes
Tooth: Cementum aging
Skull: Morphometrics, stable/radio isotopes
Fur: Hormonal assays, toxins, contaminants

g. Non-intrusive sampling (e.g., behavioral observations via focal follows and ground surveys, scat collection, passive acoustic monitoring and recording, photo-ID, photogrammetry, remote video monitoring, underwater photography); include i-vi, below, in your activity description:

i. Approach, sampling methods, and platform type;

Behavioral observations are typically made from shore using high powered spotting scopes (Questar 50x-80x magnification) and binoculars. Using high powered optics allows us to maintain a large distance between the observer and the sea otters, such that the sea otter never notices the observer. On rare occasion, behavioral observations made be made from a boat or vessel. This method is avoided unless absolutely necessary because it is impossible to use a high powered spotting scope from a vessel and binocular observations are also of poor quality due to wave action and vessel movement. Shore-based observations are far superior and are our method of choice whenever possible. In rare instances where shore access is impossible (e.g. private property situations), vessel observations may be used. We take care to maintain our distance from the otters and to not alter their behavior in any way, as doing so is counterproductive to a behavioral study.

ii. Minimum and maximum approach distance (specify different distances for each deployment method);

It is very difficult to identify a standard minimum approach distance because there is no standard distance that results in disturbance to all sea otters. In certain areas where otters encounter people or vessels regularly (e.g. Monterey, CA), they can be approached very closely (often within 25m or less) without disturbing them. In other areas where otters rarely encounter people or vessels (e.g. Big Sur, CA), sea otters become disturbed from great distances. Therefore, we always use our best judgement when determining approach distances, and do so on a case-by-case basis, taking into account the region and subpopulation of sea otters that we are working with. It is important to note that since our research is predicated on recording and observing natural wild behavior, we take great care to ensure that our presence or activities do not alter wild sea otter behavior in any way. Any alteration of wild behavior would be counterproductive to our research goals, and could result in inaccurate or biased data. Therefore, we have a very strong interest in not disturbing sea otters, and our research team and protocols are clearly designed with that goal in mind. In general, while performing behavioral observations, we rarely see the need to get closer than 100m from the sea otters, so that is a good general guideline for minimum approach distance. On occasion, we may start further away from the sea otter, but the otter may swim closer to us, since it is unaware of our presence, and perhaps even less than 100m away. In this scenario the researchers are instructed to remain low to the ground or use natural cover and minimize movement to reduce the chances of being seen or detected. There is no maximum approach distance for sea otter behavioral observations.

iii. Are researchers within sight of animals or not (e.g., from a blind)?

In general, researchers are not within sight of the animals when conducting behavioral observations. Observers usually remain at a far enough distance so that they cannot be seen by the sea otters. In rare instances where sea otters are habituated or accustomed to the routine presence of people or vessels in close proximity, the otter may see our observers, but they do not react to their presence. If an otter is ever observed to react to the presence of a researcher, action is taken on the part of the researcher to remedy the situation. This is usually done by increasing the distance between the researcher and the sea otter, but may also be accomplished by obscuring the researcher using natural features like large rocks or vegetation. Observers also take care to place themselves downwind of the focal animals, so that the sea otters do not detect the observers by smell.

iv. Frequency of observations/sampling;

During most of our research projects, an effort is made to make daily observations of each study animal. In practice, since locating every animal every day can be difficult, most study animals that remain in the study area are observed an average of 5 times per week.

v. Duration of observations/sampling per day; and

This varies based on the type of data being collected. For simple "resight" data, where the animal's location and general behavior is recorded, an observation might only take a few minutes. If the animal is fast asleep it might take longer in order to see both flipper tags, a requirement for a positive identification of the individual animal. This could take an hour or more. When collecting foraging data, a focal animal is followed for as long as reasonably possible to obtain a quality foraging bout (at least 20 dives, ideally) and may be followed for longer. A focal foraging bout may only last a few minutes, but could last several hours. When collecting observational activity budget data, a focal follow of a single individual sea otter is performed. A resight (behavior and location of the otter) is done every 10 minutes throughout the continuous activity budget. A single activity budget may last for as little as 6 hours, or as many as 24 continuous hours, depending on the goals of the project. It is important to note that the sea otter is never aware that it is being observed during resights, foraging bouts, or activity budgets. The observations are all clandestine. Any detection of the researcher by the sea otter could bias our data and results.

vi. If conducting underwater photography/videography, specify the method (e.g., snorkeling, underwater pole cam, or divers using typical gear or rebreathers) and number of people in the water at a given time, including the safety diver/snorkeler.

No underwater photography or videography is requested in this permit.

h. Testing methodologies on captive-held animals; include i-iii, below, in your activity description:

i. A description of the methodologies and equipment to be used;

None. We are not requesting permission to do this under our permit. We are collaborators on a separate permit with the Monterey Bay Aquarium that deals with testing methodologies on captive-held animals.

ii. Duration and times of testing and data analyses; and

N/A per above.

iii. Methods used to decondition the animals that will be released to the wild after testing.

N/A. Note that although we are currently testing new smart flipper tag technology on captive otters at the Monterey Bay Aquarium, the testing falls under the conditions of a separate captive research permit that is issued to the Monterey Bay Aquarium. They are a collaborating institution with many aspects of our research program, especially the projects involving advancement in tagging technology. We do not request any separate or new approvals to test methodologies on captive otters, since our current collaborative activities are permitted under the existing captive permit at the Monterey Bay Aquarium.

i. Other procedures/activities; list each additional procedure/activity and provide a detailed description of each, including all appropriate mitigation measures (note, we might contact you

with follow-up clarification of methodologies), novel procedures, and any procedures involving active acoustic or hearing studies).

We are requesting a continuation of the collection of salvaged specimens (carcasses and/or parts) from beaches and the clarification that this may occur throughout the range of the Southern sea otter, and beyond, since dead otters sometimes wash up extralimitally and present especially interesting cases when determining the cause of death. Table 1 states that we reserve the right to collect samples from carcasses of sea otters that have stranded anywhere in the state of California. These samples include the entire carcass for necropsy, but specifically: the collection of adipose tissue, external pathology, liver biopsy, premolar tooth, all teeth, skin plugs, vibrissae, baculum, skull and fur from the carcass. The recovery of sea otter carcasses provides an invaluable opportunity for determining the most important causes of death and threats facing the wild sea otter population. We work with our partners at the California Department of Fish & Wildlife to recover and necropsy beach-cast sea otter carcasses throughout the state.

21. For each procedure/activity, provide the information in a-j, below, including the maximum number of animals of each species expected to be taken by the procedure annually, broken down by sex and age class; the number of takes per animal per year; and an estimate of the number of animals of the study species that might be incidentally harassed (i.e.,# of non-target animals of your study species that might be harassed by your activities). Also, include the time-periods and specific locations of the takes. This information may be provided in table format such as:

Note that although we have many takes (over 600) left over on our existing (recently expired permit), for the sake of simplicity we are not requesting that any of those takes be carried over. We just present the number of takes we are requesting for the 5-yr duration of this renewal.

Table 2

a. Species	b. Procedure / Activity	c.Level A or Level B Harassment *or other Take**	d.Age Class (see question 23, below)	e. Sex	f.Max. # Animals Per Year	g.Max. # Takes Per Animal Per Year	h.Max. # non-target conspecifics incidentally harassed	i.Time-period	j. Location
Enhydra lutris nereis	Capture	600	All	Both	120	3	1250	5-year permit duration	Entire Range

Table 3. This table states the total number of captures we are requesting for the duration of this 5-yr permit. It also states that of the total captures, a sub-sample will undergo anesthesia and sampling, and a further subsample with undergo surgery to implant or remove instruments. We are requesting authorization for Level B harassment of up to 1250 (250/year) during capture activities.

	TOTAL TAKES (CAPTURES)	TOTAL FOR ANESTHESIA/TAG/TISSUE SAMPLES	TOTAL FOR SURGERY IMPLANT/EXPLANT	LEVEL B HARASSMENT (FOR 5 YR DURATION OF PERMIT)
TOTAL REQUESTED	600	300	150	1250

22. Will any female-pup/calf/cub pairs be targeted for any of the proposed research activities? If so, describe how you would minimize impacts on pups/calves/cubs and associated females during each of those activities.

Yes, female-pup pairs may be targeted for our research activities. Since most of our research aims to answer questions about reproduction, survival, and population dynamics, avoiding the capture of mothers and pups would severely bias our research and result in inaccurate conclusions.

Immediately after capture, the mother and pup will be transferred to a holding box, like all captured otters. In general, the mother and pup are placed in the same holding box. However, certain instances may dictate that holding the mother and pup in separate boxes would be the most prudent course of action. For example, if the pup is quite small and the mother is not showing clear maternal behavior towards the pup, it might be safer to keep the pup in its own box, to prevent any possibility of incidental injury to the pup. At the other end of the spectrum, sometimes very large pups are as big as the mother. In this case, the mom and pup might be placed into separate holding boxes so that both otters can have sufficient space. Mothers and pups, regardless of age or pup size, are always released together to reduce the chance of separation.

Females with pup may be subjected to all the normal veterinary procedures that any captured sea otter would normally be subjected to. This includes surgery for the implantation of VHF radio transmitters. In addition, sterile oxytocin (20 units/ml) may be injected intramuscularly to facilitate milk letdown in lactating females. Oxytocin, a hormone produced by the hypothalamus stimulates contraction of the smooth muscle of the mammary glands to release milk. We will only attempt to collect milk samples from females with dependent pups, no pregnant females or females without pups will be given oxytocin.

In general, the size of the pup dictates what samples, tags, or procedures are performed on the pup. The pup must weigh at least 20 lbs to qualify for and instrument implantation. Additionally, only pups greater 11 lbs will be flipper tagged. Pups weighing less than 6 lbs will not be PIT-tagged. Pups of all sizes may have morphometric data (e.g. length, weight) and demographic data (e.g. sex) collected.

Given that our estimated time from capture to release is 2 hrs, it's fair to say that the max time that a mother and pup would be separated is for this entire 2hr duration. In practice, the timing is much shorter, since the mother and pup usually share a holding box. If the mother is anesthetized for surgery, the pup will only be separated from the mom during the surgical procedure. This is typically <1 hr.

We take all the necessary precautions to ensure that a separation of mother and pup does not occur. In fact, due to our precautions and the strong mothering instinct of female sea otters, a separation would be considered an extremely rare event. Therefore, reuniting a mother-pup pair is something that is almost never required in our work. As one of our precautions, we observe the behavior of the mother and pup together, in the holding box, to make sure their behavior is still indicative of a bonded pair (e.g. mother holding or grooming pup) before releasing them. We will also employ a "soft release" technique with moms and smaller pups. This method involves submerging the box on its side, about halfway in the water at the side of the boat, then slowly opening the door of the box. The otters will usually calmly swim out of the box.

However, in the extremely unlikely event of a separation, this would probably occur by virtue of the mother immediately leaving the holding box upon release, and leaving the pup behind in the box. This is only a concern with a small pup since larger pups are capable of swimming on their own and catching up to their mother. If a small pup is left behind in the box, the persons conducting the release will immediately remove the pup from the box and place it in the water to float. Releases are always done with the boat placed upwind so that the mother can smell her pup if she initially leaves without it. This will aid her in relocating her pup when she inevitably returns to look for it. In an extreme situation where the mother doesn't immediately return for the pup, the pup is held high in the air so that the sound of the pup's call can travel a greater distance, enticing the mother to return and retrieve her pup. If this still does not work, the pup will be left at the site of release, and the boat will back away. Our shore spotters will monitor the pup through a high-powered spotting scope to see if the mother returns to claim the pup. Should these attempts fail and the mother does not return, the pup will be rescued by the boat crew, and brought back into veterinary team. At the discretion of the lead veterinarian, if it is deemed that the pup has truly been abandoned, the pup may be raised in captivity at the Monterey Bay Aquarium as part of their surrogacy program, and could be released back into the wild once mature. We have never had to resort to this final step in many hundreds of wild sea otter captures.

23. Define each age class listed in your response to question 21(d), above, for each species (i.e., list the range of months or years (or mass for otters) constituting each age class); provide the minimum age (or mass) that animals will be targeted for take activities; and indicate whether females with calves/pups/cubs less than that minimum age will be targeted for take activities?

We listed "all" for age classes targeted in 21(d). This is because of the nature of our research. It is impossible to do a study looking at population-level effects concerning movement patterns, diet, and survival if you only target certain age classes. Furthermore, it is difficult to determine the age class of a sea otter until have you have captured an examined the otter. The most reliable estimator of age comes from a dental examine, which requires a captured and anesthetized sea otter. Still, when we discuss different age classes, we break them down as follows:

Dependent pup
- Very small (<3 weeks old)
- Small (3-10 weeks old)
- Large (>10 weeks old)

Juvenile: 6 months to 1 year old
Sub-adult: 1-3 years old
Adult: 3-10 years old
Aged (Old) Adult: 10+ years old

As mentioned in responses to 10(h), whenever possible, very small/newborn pups are generally avoided when attempting to capture sea otters. However, very small pups are sometimes captured anyway, since they can be difficult to see. Even if they are seen, age can be difficult to determine depending on sightability of the pup, ocean conditions, and the experience level of the observer. If a very small newborn pup is observed, we will usually not attempt to make the capture of the mother-pup pair. But because this cannot always be determined ahead of time, we are requesting permission to capture all age classes of sea otters, including small pups. We just wanted to make it known that when we are conducting sea otter captures we always have the best interest of the sea otters in mind. If a marginal situation presents itself in terms of the presence of a very small pup (as determined by our experienced personnel) we will always act in the best interest of the sea otters. The actions we take could include the avoidance of the mother-pup pair, but this depends on the situation. We don't have any data to support any assertion that capturing tiny pups is more risky than capturing larger pups, but the small size of the pups leads us to act with an abundance of caution. Pups must weigh at least 11lbs to qualify for flipper tagging, and must weigh at least 20lbs to qualify for instrumentation.

24. Describe the precautions that will be taken to minimize the likelihood that harassment of non-target individuals of the study species will occur and the actions that will be taken should harassment occur.

As previously described in the response to question 10(f), any incidental harassment is almost always due to the habit of sea otters resting in groups or rafts. When capturing target otters in a raft, nearby otters may be disturbed. We always try to minimize the disturbance or incidental harassment of non-target otters. The rebreather diver techniques described previously are the best way to minimize incidental harassment, because the divers remain undetected for the entire dive, until the moment of capture. Our captures are most successful when we are completely undetected, so minimizing incidental harassment is inherent to the success of our work. When possible, we avoid targeting an animal when it's in a very large group of otters. The odds of successful capture decrease when the target is resting in a large group. Sometimes this cannot be avoided, however, most capture attempts are on solo animals, animals in pairs, or otherwise small rafts.

25. Explain how you determined that your methods involve the least possible degree of pain and suffering and why there are no feasible alternative methods to obtain the desired data or results.

Because of the broad, comparative nature of our research, captive animals are not appropriate surrogates for behavior or habitat use studies of wild sea otters, nor will they allow assessment of the survival, reproductive success, health and body condition of their wild counterparts. The only way to conduct these types of studies is through the capture and marking of individual wild sea otters. In order to continue to study behavioral, life history, and physiological characteristics of the threatened southern sea otter and to compare populations across geographical regions, wild animals from those populations must be sampled. When possible, data and/or samples will be obtained from beach-cast carcasses rather than live-captured animals.

Our methods have proven efficient and effective for many decades, but more importantly, they have also been refined at every available opportunity. We have learned a lot over the years and we believe that our current techniques represent the best and safest methods in existence, for this type of research.

The techniques described in this permit application have been honed and refined over the past 25+ years in order to reduce the likelihood of adverse health impacts, mortalities, pain, or suffering. Since sea otter capture and tagging is very specific and highly specialized work, there is no industry standard for the "least possible degree of pain and suffering" in this species. As a result, every action we take is aimed at minimizing pain and suffering during the capture and tagging process. The list of co-investigators includes more than 12 licensed veterinarians and vet techs, as well as biologists with a combined 400+ years of experience capturing, tagging and handling wild sea otters. As such, the assemblage of veterinarians and biologist on this permit comprises the most experienced sea otter personnel in the world, and we take pride in our ability to set the standard of safe and responsible handling of sea otters. We also heavily rely on the experience of our 12 veterinarians when it comes to ensuring that the least possible degree of pain and suffering is being employed through our research. Our veterinarians are all experienced in sea otter health assessments and veterinary care, but they come from many different institutions and all have diverse backgrounds in the care of marine mammals, as well as a huge diversity of other species from terrestrial mammals to reptiles, birds, fish and invertebrates. The invaluable experience and knowledge base of this incredible team of veterinarians and sea otter biologists makes them exceeding qualified to determine the standards of care that our study animals receive, and every member of our team always acts with the best interest of the sea otters in mind.

Some examples of the protocol changes that we have made to reduce the likelihood of adverse effects, and minimize pain and suffering include:

- Wrapping of plastic hose around all metal parts of Wilson traps and dip nets that otters could potentially bit so as to prevent tooth damage
- Extensive improvements to capture boxes (increased ventilation, no “bitable inner edges”, false bottoms that keep the otters fur separate from water or fouling materials)
- Reducing total animal processing time to under 2 hours
- Better management of otter thermal conditions prior to surgery (including sea-water soaks immediately prior to anesthesia)
- Modification of the anesthetic and surgical procedures to reduce overall invasiveness and improve recovery time
- Switching to temperature-sensitive PIT tags so as to be able to closely monitor body temperature in real-time after drug reversal (but prior to release) to ensure appropriate surgical recovery.

Because of these and other protocol changes, we have continued to improve the outcomes for study animals and reduced the potential for accidental lethal takes to very low levels, while also minimizing any pain and suffering that the otters might incur. We take this very seriously, and have spent untold hours and funds ensuring the well-being of the sea otters we capture.

26. Provide: a) an estimate of the possible number of unintentional deaths or serious injuries that might result from your research activities; b) the number of unintentional and intentional (via euthanasia for humane purposes if an animal is seriously injured) deaths or serious injuries you seek approval for annually; c) the steps you will take to reduce the likelihood of deaths or injuries; and d) if euthanasia might occur, provide the method of euthanasia (e.g., gunshot, drug, etc.) and who would conduct the euthanasia procedure.

Our current permit requires notification of the permit office after one mortality that occurs during capture operations (where there is reasonable cause to suspect that the death was caused by our activities and is thus an accidental lethal take), and cessation of all activities after 2 such mortalities. We would therefore request no more than 2 accidental lethal takes for this permit renewal (with the specification that post-mortem necropsies by a veterinary pathologist indicate that the mortalities in question were indeed caused primarily or entirely by our activities rather than by some unrelated factor). In the unlikely event that a moribund animal needs to be humanely euthanized, this will be determined by the lead veterinarian, and euthanasia will be by drug injection.

28. If a female animal accompanied by calf/pup/cub(s) dies during research activities, specify the disposition of the associated calf/pup/cub(s).

In this highly unlikely scenario, we have a very good solution that is generally not available to other marine mammal researchers. Since we work collaboratively with the Monterey Bay Aquarium, we have the option of admitting the orphaned pup into their surrogacy program. This program allows the pup to be fostered by a captive sea otter mother until it has reached maturity, at which time the pup can be re-released to the wild. The Monterey Bay Aquarium surrogacy program has a long and successful track record for reintroducing stranded or orphaned pups back into the wild. This would be our first and most desired outcome in this unfortunate scenario. If the Monterey Bay Aquarium cannot accommodate the pup (i.e. if there is no room) we can inquire with other captive facilities. If placement for the pup is impossible, the only alternative would be euthanasia.

29. If biological samples are to be collected or received domestically, provide responses to a through j, below, for each individual animal per species. This information, or part of the information, may be provided in table format such as the table below. (Note: if your only proposed activity is to transfer dead marine mammal specimens for purposes of public display or scientific research, complete application Form 3-200-87).

Table 4. The following samples will be taken from both sexes of southern sea otters of all age classes, from live and dead specimens with the following exceptions: no samples will be taken from live pups less than 11 pounds in weight and no pre-molar teeth will be extracted from live pups or juvenile sea otters. Up to 120 southern sea otters will be sampled per year and individuals will be sampled no more than 3 times per year. All samples listed have been approved on our previous permit.

a. Species	b. ID #	c. Sex	d. Source (Wild or Captive/Live or Dead)	e. Birth Date or age class	f. Type of Samples (blood, tissue, DNA)	g. Number of animals sampled annually	h. Number of times each animal will be sampled annually	i. Packaging and Preservation of samples	j. Use/Disposition of Samples
Enhydra lutris nereis	N/A	Both	Wild/Live	All >11 llbs	Blood	60	3	Stored at Monterey Bay Aquarium or CA DFW	Hematology, clinical chemistry, infectious disease monitoring, biomarkers, contaminants
Enhydra lutris nereis	N/A	Both	Wild/Live	All >11 llbs	External Swabs (integument, oral cavity, rectum, genital orifice)	60	3	Stored at Monterey Bay Aquarium or CA DFW	Infectious disease (bacterial, fungal, parasitic, viral), contaminants, gene ics
Enhydra lutris nereis	N/A	Both	Wild/Live	All >11 llbs	Saliva	60	3	Stored at Monterey Bay Aquarium or CA DFW	Hormonal assays
Enhydra lutris nereis	N/A	Both	Wild/Live	All >11 llbs	Feces (from animal)	60	3	Stored at Monterey Bay Aquarium or CA DFW	Diet assessment, infectious disease (bacterial, fungal, parasitic, viral), contaminants, biotoxin, hormonal assay
Enhydra lutris nereis	N/A	N/A	Environment	N/A	Feces (from environment)	N/A; No limit	N/A; no limit	Stored at Monterey Bay Aquarium or CA DFW	Diet assessment, infectious disease (bacterial, fungal, parasitic, viral), contaminants, biotoxin, hormonal assay
Enhydra lutris nereis	N/A	Females	Wild/Live	All adult	Milk	60	3	Stored at Monterey Bay Aquarium or CA DFW	Nutritional content, fatty acid analysis, contaminants
Enhydra lutris nereis	N/A	Both	Wild/Live	All >11 llbs	Urine	60	3	Stored at Monterey Bay Aquarium or CA DFW	infectious disease, toxins, urinalysis, contaminants
Enhydra lutris nereis	N/A	Both	Wild/Live	All >11 llbs	Adipose Tissue	60	3	Stored at Monterey Bay Aquarium or CA DFW	Fatty acids, contaminants
Enhydra lutris nereis	N/A	Both	Wild/Dead	All	Adipose Tissue	N/A; no limit	N/A; no limit	Stored at Monterey Bay Aquarium or CA DFW	Fatty acids, contaminants
Enhydra lutris nereis	N/A	Both	Wild/Live	All >11 llbs	External pathology (integument, oral cavity, genital orifice)	60	3	Stored at Monterey Bay Aquarium or CA DFW	Histopathology, genetics, etiopathogenetic investigation
Enhydra lutris nereis	N/A	Both	Wild/Dead	All	External pathology (integument, oral cavity, genital orifice)	N/A; no limit	N/A; no limit	Stored at Monterey Bay Aquarium or CA DFW	Histopathology, genetics, etiopathogenetic investigation

Enhydra lutris nereis	N/A	Both	Wild/Live	All adult	Liver biopsies	60	3	Stored at Monterey Bay Aquarium or CA DFW	Histopathology, toxicology, contaminants, genetics, chemical analysis (ie, Vit A analysis)
Enhydra lutris nereis	N/A	Both	Wild/Dead	All	Liver biopsies	N/A; no limit	N/A; no limit	Stored at Monterey Bay Aquarium or CA DFW	Histopathology, toxicology, contaminants, genetics, chemical analysis (ie, Vit A analysis)
Enhydra lutris nereis	N/A	Both	Wild/Live	All adult	Premolar tooth	60	1	Stored at Monterey Bay Aquarium or CA DFW	Cementum aging
Enhydra lutris nereis	N/A	Both	Wild/Dead	All	Premolar tooth	N/A; no limit	N/A; no limit	Stored at Monterey Bay Aquarium or CA DFW	Cementum aging
Enhydra lutris nereis	N/A	Both	Wild/Live	All >11 lbs	Skin plugs	60	3	Stored at Monterey Bay Aquarium or CA DFW	Genetics
Enhydra lutris nereis	N/A	Both	Wild/Dead	All	Skin plugs	N/A; no limit	N/A; no limit	Stored at Monterey Bay Aquarium or CA DFW	Genetics
Enhydra lutris nereis	N/A	Both	Wild/Live	All >11 lbs	Vibrissae	60	3	Stored at Monterey Bay Aquarium or CA DFW	Stable isotope analysis
Enhydra lutris nereis	N/A	Both	Wild/Dead	All	Vibrissae	N/A; no limit	N/A; no limit	Stored at Monterey Bay Aquarium or CA DFW	Stable isotope analysis
Enhydra lutris nereis	N/A	Males	Wild/Dead	All	Baculum	N/A; no limit	1	Stored at Monterey Bay Aquarium or CA DFW	Morphometrics, stable/radio isotopes
Enhydra lutris nereis	N/A	Both	Wild/Dead	All	Tooth	N/A; no limit	N/A; no limit	Stored at Monterey Bay Aquarium or CA DFW	Cementum aging
Enhydra lutris nereis	N/A	Both	Wild/Dead	All	Skull	N/A; no limit	1	Stored at Monterey Bay Aquarium or CA DFW	Morphometrics, stable/radio isotopes
Enhydra lutris nereis	N/A	Both	Wild/Live	All >11 lbs	Fur	60	3	Stored at Monterey Bay Aquarium or CA DFW	Hormonal assays, toxins, contaminants
Enhydra lutris nereis	N/A	Both	Wild/Dead	All	Fur	N/A; no limit	N/A; no limit	Stored at Monterey Bay Aquarium or CA DFW	Hormonal assays, toxins, contaminants

In addition: All animals captured or sampled under this permit will be wild born. Any specimens collected will be transferred to, and archived at, the Marine Wildlife Veterinary Care and Research Center, Department of Fish and Wildlife, located at Long Marine Lab in Santa Cruz. They may be retrieved from this location for further analysis. Unused portions of samples will be archived at either the Marine Wildlife Veterinary Care and Research Center (California Department of Fish and Wildlife, located at Long Marine Lab in Santa Cruz) or the Monterey Bay Aquarium, where appropriate -80 freezers (with redundant power back-up) exist. A database is maintained that provides the current disposition of each sample at any point in time.

k. Provide a detailed description of the source of the specimens, including the circumstances under which the animals were/will be taken. For example, this might include the following sources:

The source of all samples will be from live captured wild otters as previously described, or from stranded/dead/beach-cast carcasses. Because of the broad, comparative nature of our research, and the need to obtain representative data from throughout the range (and over all seasons and across years) on all population parameters, sampling may occur at any location within the current range of southern sea otters (Fig 2), or extralimitally if an otter strands outside of the current range, and at any time of year within the time period covered by the permit.

i. Animals stranded alive or dead;
Samples may be obtained from dead, beach-cast sea otter carcasses. These are noted in Table 1 and Table 4.

ii. Animals killed during legal subsistence harvests;
No, subsistence harvest of sea otters does not exist in California

iii. Animals killed incidental to legal commercial fishing operations;
Yes. Unlikely, but an otter carcass that is killed as a result of commercial fishing activities could be sampled. Sometimes the cause of death is not immediately apparent until the samples are taken and the necropsy conducted.

iv. Samples from other authorized researchers or collections;
We will not be obtaining samples from other researchers or collections. All samples will be obtained by us, via this permit.

v. Soft or hard parts that are sloughed, excreted, or discharged naturally;
No, N/A

vi. Samples that will be/were intrusively collected from captive-held animals;
No, N/A. Our samples are from wild animals.

vii. Samples that will /were collected from wild animals.
Yes. As previously described, our samples will be from live-captured wild otter or dead beach-cast carcasses of wild otters.

l. If collecting samples from live animals, describe how the samples were/will be collected, including animal handling and sample collection protocols.
All the samples already listed will be collected by one of the veterinarians or veterinary staff under the supervision of a veterinarian listed on this permit. All samples are collected while the otter is sedated. Some non-invasive measurements may be collected without sedation (e.g. weight) but the animal is sedated for all actual sampling. Blood is collected intravenously from the jugular vein. External swabs are collected manually, by swabbing the areas or orifice specified. Saliva is collected manually from the mouth. Fecal samples are collected manually from the rectum. Milk is manually expressed from the mammillary glands of lactating females. Urine is collected via cystocentesis (syringe and needle) or occasionally “free catch.” Adipose tissue is manually collected via surgical excision during the surgical procedure. External pathology is collected manually usually via swab. Liver biopsies are taken manually using clam-shell biopsy forceps during the surgical procedure. The premolar tooth is removed manually using a dental elevator. Skin plugs are collected manually from the webbing of the hind flipper using a sterile leather

punch. This procedure is necessary to apply flipper tags, so the skin plugs are saved for genetic analyses, providing multiple data types/uses for a single procedure. Vibrissae are manually plucked from the muzzle. Fur is manually plucked from the exterior pelt.

m. For samples received domestically from U.S. permitted researchers, include the researcher's name, affiliation, and permit number under which samples will be/were collected. (Note: if samples are to be imported, you must answer question 12, above).
N/A

30. Provide a list of all personnel that will be involved in the project, identifying each as either a principal investigator or co-investigator, their project duties/responsibilities, and a brief description or CV that demonstrates their experience and expertise to perform their designated duties, including knowledge of the marine mammal species that is/are the subject of this application.

Applicant (Project Lead): Joseph Tomoleoni, Biologist, Sea Otter Project Leader, U. S. Geological Survey, Western Ecological Research Center. Joe's primary interests are in areas of population, behavioral and community ecology. He has worked with sea otters in Alaska, California, and Washington for over 10 years and has extensive experience with capture, tagging, and handling of wild otters. Joe is a rebreather diver and has participated in more than 40 sea otter capture events, and more than 150 sea otter capture dives under previous versions of this permit. Joe has prior experience as the Project Lead for sea otter captures, including as the designated interim project lead for otter re-captures in Santa Barbara, California (2014), in the absence of the previous permit holder, Tim Tinker, and as the lead for all sea otter captures that occurred in 2018.

Existing Permittees (Co-Investigators): Brian Hatfield, Michael Kenner, Jack Ames, Michelle Staedler, Daniel Costa, Benjamin Weitzman, Colleen Young, Michael Murray (DVM), Terrie Williams, James Estes, Mike Harris, James Bodkin, Daniel Monson, George Esslinger, Seth Newsome, Brent Hughes, Zachary Randell, Christine Fiorello (DVM), Nancy Anderson (DVM), Lesanna Lahner (DVM), Raymond Wack (DVM), Heather Harris (DVM), Melissa Miller (DVM), and Christine Kreuder-Johnson (DVM).

AMMENDMENT REQUEST: We would like to add the following personnel to our permit. Their CVs are included in this application packet.

<u>M. Tim Tinker, PhD:</u> Dr. Tinker was the previous P.I. and permit holder for this permit. He was also the previous Sea Otter Project Leader for USGS before leaving the service in 2017. We would like Tim to be listed on this permit as a co-investigator, since he is still involved with our research program, just no longer the leader. Tim has over 25 years of experience working with sea otters in California, Alaska, Russia, Washington, and British Columbia, and has participated in countless sea otter capture events, leading most of them.

<u>Dave Casper, DVM</u>: Dr. Casper serves as the Director of Veterinary Services, as well as the attending veterinarian for UCSC's Long Marine Lab and Moss Landing Marine Labs, while also performing services as a contract veterinarian for the Monterey Bay Aquarium. He has more than 30 years of experience working with a variety of marine mammals and other marine megafauna in the field. Dr. Casper has extensive veterinary experience with Southern sea otters, having worked extensively with sea otters for the past 18 years.

<u>Nicole Thometz, PhD</u>.: Dr. Thometz is an assistant professor at the University of San Francisco, and is a broadly trained physiological ecologist who specializes in marine mammal physiology, ecology, and behavior. Nicole has approximately 10 years of

experience working with captive and wild sea otters in a research capacity, and has assisted in numerous sea otter capture events since 2008. A new USGS research project collaborating with the Thometz Lab at USF will aim to investigate the foraging energetics and diet composition of southern sea otters at the northern extent of their range.

<u>Shawn Johnson, DVM</u>: Dr. Johnson is Director of Veterinary Science at The Marine Mammal Center and oversees all of the Rescue, Animal Care, Diagnostic Services, and Research activities. Dr. Johnson has more the 20 years of marine mammal veterinary medicine experience and has cared for sea otters in rehabilitations at the Alaska SeaLife Center and The Marine Mammal Center and participated in two sea otter captures trips performing anesthesia, sampling, and implant surgeries under the guidance of Dr. Mike Murray.

<u>Cara Field, DVM</u>: Dr. Cara Field is the Staff Veterinarian at The Marine Mammal Center (TMMC) in Sausalito California, since October, 2014. Her primary roles include managing the care and rehabilitation of our marine mammal patients including sea otters, as well as carrying out research projects and teaching our veterinary intern and visiting veterinary residents, international vets and students among others. Sea otter specific experience includes primary medical care of 2 captive sea otters at Audubon Nature Institute for 2.5 years, medical care of 5 captive sea otters at Georgia Aquarium for 2.5 years, primary responsibility for the rehabilitation of sea otters at TMMC, collaboration with the Monterey Bay Aquarium sea otter rehabilitation program, participation in sea otter transmitter implant surgeries, and collaborator with the US Fish and Wildlife and OWCN response groups.

<u>Claire Simeone, DVM</u>: Dr. Claire Simeone is a veterinarian with The Marine Mammal Center and has seven years' experience working with marine mammals, including sea otters. She has provided medical care for sea otters both in a rehabilitation and captive setting, and has sedated roughly a dozen southern sea otters. She has performed both implant and explant surgeries under the observation of Dr. Mike Murray.

<u>Marissa Young</u>: Marissa started at the Monterey Bay aquarium in August 2004 as an Animal Care volunteer in the Sea Otter Program. She volunteered for a 5 ½ hour shift once weekly. She began a full-time paid staff position at the aquarium in August 2005, again covering animal care with the Sea Otter Program and working with Dr. Mike Murray in the capacity of a Registered Veterinary Technician. That equates to almost 15 years of experience with capture, handling, restraint, medical care and anesthesia monitoring for southern sea otters.

<u>Julie Yee, PhD.</u>: Dr. Yee is the new Principle Investigator for the USGS Santa Cruz Field Station's sea otter research program. Dr. Yee is trained as a statistician, but is currently assimilating into to her new role as program PI. Although she has little prior experience working with sea otters, her involvement in this permit is necessary as the new lead of the program. Dr. Yee will have the opportunity to be involved with sea otter captures and learn techniques from the many other experienced researchers listed here, but her opportunities to work hands-on with sea otters will be limited.

31. Describe how you will collaborate or coordinate with other researchers in your study area. Who are they? Explain how this will occur and how it will minimize negative impacts on the species. For example, will it involve sharing resources, samples or data; timing surveys to minimize disturbance, etc.?

Our research program has a long history of collaborating with other researchers in our immediate area, as well as those around the country. Any time we conduct sea otter captures we work directly with the Monterey Bay Aquarium and the California Department of Fish & Wildlife. Descriptions of the roles of our collaborators follow below:

USGS Western Ecological Research Center: The lead agency conducting sea otter research in California. Secures permits and funding, develops proposals for novel research, spearheads the effort to better understand sea otters and their role as keystone predators in nearshore ecosystems. During otter captures, USGS Project Lead serves as the overall leader for capture operations, but makes decisions with senior staff from collaborating agencies and institutions. USGS provides vessel support, divers, boat operators, shore spotters, and general assistance during capture. USGS also provides most of the equipment, including holding boxes other specialized items. The Survey is ultimately responsible for the collection of all data on the project. USGS performs analyses and writes up results for publication in reports and peer-reviewed journals. The findings of these USGS-led studies are useful to the USFWS and a host of other agencies in making management decisions regarding the status and future of Southern sea otters.

Monterey Bay Aquarium: Provides primary veterinary support and expertise, led by veterinarian Dr. Michael Murray. MBA provides animal health care staff including vet techs, and provides access to their state-of-the-art Animal Health Lab, which allows the otters to be processed and cared for in an exceptional facility that would rival any high end hospital in the country. The veterinary team also contributes drugs and medication involved in the work. Additionally, MBA provides leadership and coordination of all shore activities. MBA also provides skilled shore spotters during capture operations, as well as general hands to help transport animals and equipment. MBA occasionally provides some vessel support. The Monterey Bay Aquarium is very involved in the post-release monitoring of study animals, and assists USGS with the primary data collection duties for the duration of each study.

California Department of Fish & Wildlife: Provides staff support in the form of boat drivers, boats, and equipment for sea otter captures. May provide some veterinary assistance. Provides blood processors and the equipment necessary for this task (centrifuges, freezers, etc.). CDFW also provides a Mobile Veterinary Lab for more remote capture operations. Because CDFW employs experience pathologists, they perform the necropsies on most dead sea otters that wash up in California, including all study animals.

In addition to the core collaborators above, we also receive logistical, staff, equipment, and analytical support from various other agencies and institutions, including the United States Fish & Wildlife Service, the USGS Alaska Science Center, the University of California Santa Cruz, the University of California Davis, the University of New Mexico, the Elkhorn Slough National Estuarine Research Reserve, the Santa Barbara Zoo, the Marine Mammal Center, and many others.

32. If you intend to conduct research on animals in a captive-holding facility such as a zoo or aquarium, provide documentation showing that the facility(ies) has authorized you to conduct your proposed activities.

N/A

33. Animal Welfare Act (AWA) Compliance (for research on live animals only): AWA requirements apply to all research facilities, which include institutions, organizations, or people that use or intend to use LIVE animals in research, tests, or experiments; AND, that receive funds under a grant, award, loan, or contract from a department, agency, or instrumentality of the U.S. for the purpose of carrying out research, tests, or experiments, or acquires or transports the animals in commerce. Provide the following documentation:

N/A. We will not be housing any animals for research purposes thus APHIS/AWA registration is not required. We capture and sample sea otters in the wild and release them immediately post-processing.

a. Registration under the AWA as a research facility:
i. Attach a copy of your APHIS certificate of registration as a research facility, or for Federal facilities, a letter from your Institutional Officer that you are compliant with applicable requirements for scientific research under the AWA; OR
ii. If your facility does/will not conduct activities requiring registration under the AWA, attach a letter from APHIS confirming that registration is not required.

N/A. We will not be housing any animals for research purposes thus APHIS/AWA registration is not required. We capture and sample sea otters in the wild and release them immediately post-processing.

b. Institutional Animal Care and Use Committee (IACUC) documentation: If your facility is registered as a research facility under the AWA or is a Federal research facility (see a.i), attach the applicable IACUC documentation from the list in i-iii, below. Please note that all activities that involve an invasive procedure, harm, or materially alter the behavior of an animal under study, even if the activities are carried out in the field, are subject to IACUC review and approval. See (AWA regulations and standards for definition/explanation of covered research activities.):
i. Attach a copy of your final protocols with the IACUC signed approval; OR
ii. Attach a copy of your proposed protocols to be reviewed by your IACUC along with an explanation as to how and when the protocols will be reviewed (Note: A copy of your final signed protocols and certification will be required prior to permit issuance.); OR
iii. Attach the IACUC determination that your research activities are not subject to IACUC review and approval.

Our ACUC approval of our capture and handling SOPs has been granted. Please see attached ACUC approved SOP for sea otter research.

c. If your facility is not registered as a research facility under the AWA, please provide an explanation of how your take activities are reviewed and monitored to assure that the proposed takes are humane (i.e., using the method that involves the least possible degree of pain and suffering).

N/A

Innovation Fund 2018 Proposal

Next Generation Wildlife Tracking: A New Paradigm for Environmental Monitoring and Data Retrieval through Hybrid Heterogeneous Networks of Tagged Animals

The problem and the opportunity:

Advanced animal tracking devices that couple cutting-edge technologies with our increasing need for ecological data will be critical tools for managing and conserving species under future land use and climate conditions. In addition to optimizing the size of telemetry units for use on small or sensitive species, new paradigms for collecting, storing and transmitting data on animals and their environments are needed to further advance the next generation of wildlife tracking devices. We propose a follow-on effort to our previous Next Generation Wildlife Tracking development work. Phase 3 of our USGS-NASA collaborative project will mature the two tag architectures developed under Phase 1 (satellite communications tag) and Phase 2 (networked tags), and will explore new hybrid architectures enabled by using a mixture of the two tag types (e.g. heterogeneous networks).

Our successful Phase 1 and 2 efforts have resulted in several advances that address issues associated with modern day telemetry units. During Phase 1, we developed a novel tag to satisfy the challenging goals of providing a light-weight, energy-efficient, and low-cost device that could transmit geolocation and environmental sensor data via commercial satellite (Fig. 1). Additionally, research conducted in Phase 1 identified the need for a smaller, lighter, lower-cost tag that could collect and exchange data with other tags. Such information sharing among animals is a novel approach to maximizing data collection and delivery that has the added benefit of detecting patterns of association among individuals and subpopulations. In a peer-to-peer tracking network, animals can exchange stored location, activity, body condition, and environmental data when in close proximity, thereby improving energy-efficient data recovery (one individual can upload data from many; Fig. 2) and shifting the wildlife telemetry framework from geospatial tracking of a single animal, to one that can also acquire data about population connectivity.

In Phase 2, we developed peer-to-peer tracking capabilities (Fig. 3) and refined the early prototype satellite-communications tag created in Phase 1 to incorporate a unique antenna capable of both receiving GPS signals and transmitting to the Globalstar satellite constellation. Our Phase 2 work has advanced both devices, as well as a base station design for use with the networked tags, to the point of readiness for field testing. Research in Phase 2 also indicated the potential for "hybrid architectures" comprised of both multiple, interconnected networked tags, and one or more satellite tags. Such hybrid architectures offer the potential to leverage species associations with surrounding animal populations, and provide a mechanism for the data acquired by networked tags on small species to be collected by the satellite tags sited on larger species and ultimately relayed to scientists.

The overarching goal of our collaborative USGS-NASA Next Generation Wildlife Tracking project is to develop low-cost, modular hardware and custom software that will allow scientists to tailor tag technology for broad species applicability and large-scale deployments. To achieve this goal we have identified three parallel tasks for Phase 3 of our project (see timeline Fig. 4). **In Task 1**, field testing of the first generation of satellite tags, which was started in Phase 2, will be concluded and the results analyzed and incorporated into design revisions and improvements. The improved (Gen 2) satellite tags will be designed and prototypes fabricated. **Task 2** will advance the design of the networked tags. A set of base stations will be fabricated to enable field testing of the 1st-generation networked tags, and a set of tags for testing will be produced. These elements will be field-tested to assess function, radio range, and battery life. The results will be analyzed and used to evolve the tag design and prototype a Gen 2 peer-to-peer tag. For both the satellite and peer-to-peer

tags, software and hardware design and performance will be documented and published upon the completion to Gen 2 working prototypes.

Development of the hybrid architecture described above will form **Task 3**. Satellite and networked tags will be used to implement a hybrid system, which will then be tested to evaluate capabilities and suitability for the anticipated wildlife monitoring use. In particular, the achievable data throughput from the complete system will be assessed, for architecture variations of number of networked tags vs. number of satellite tags and/or base stations. The results of the **Task 3** activities will be documented in a published report. Our approach to all tasks will be open-hardware, open-software with the goal of producing low-cost reference designs that can be adopted, modified, and improved by commercial providers, universities, and other government labs. We will continue to engage with stakeholders from USGS and other agencies, including a developing NASA-BOEM project investigating employment of small satellites for telemetry data transmission.

Overall Goal or MVP (minimum viable product):

The Minimum Viable Product resulting from our collaboration will be a low-cost, miniaturized, wildlife GPS-satellite marking prototype with integrated environmental sensors optimized for size, battery life (or solar cell recharge), and peer-to-peer data transmission. To date, our team has advanced this goal by producing a miniaturized solar GPS-enabled Globalstar satellite transmitter with accelerometer capability (Fig. 2) that is 20% lighter and produced for 25% of the cost of existing commercial tags, as well as a novel peer-to-peer, solar-powered network tag and associated base station hardware. Our Phase 3 work will integrate components developed in Phases 1 and 2 to create a hybridized architecture of networked peer-to-peer and satellite tags.

Objectives and Activities:

Objectives	Activities
Reduce battery size and improve performance	Develop optimized battery using a combination of state-of- the-art technologies including commercially available batteries, NASA-Ames developed 3D-printed battery technology, and/or GaAs thin-film flexible photovoltaic cells for use in recharging batteries to extend life. **(ACHIEVED)**
Integrate environmental sensors	Incorporate between 1 and 3 exchangeable environmental sensors that are integrated into GSM or satellite data transmission systems. **(ACHIEVED – ACCELEROMETER INTEGRATED)**
Develop peer-to-peer networking capability	Build on existing hardware and communication protocols to allow wireless communication (handshake/data sharing) among tagged individuals when in close proximity, thus creating a peer-to-peer tracking network **(ACHIEVED)**.
Integrate system	Integrate Phase 1 and 2 to create a hybridized architecture that allows for networked communication among animals as well as data transmission via satellite
Test and modify designs	Throughout each task we will employ a spiral development approach in which prototype is developed and tested on one or more wildlife species, design is modified and the refined prototype is tested again.

How critical is Innovation Funding for the success of this venture?

Biotelemetry is critical for understanding both threats and conservation opportunities for the Nation's wildlife resources. Emerging technologies offer great promise for innovating wildlife tracking technology and significantly increasing the amount of information we can gain from traditionally hard-to-track species. While commercial telemetry companies have decreased device size and increased location accuracy, progress towards more effective tracking devices has been slow due to limited private-sector research and development. New information from cutting-edge telemetry devices has great applicability for USGS Ecosystems, Climate and Land Use Change, and Core Science Systems; however, development of the

necessary technology is somewhat outside the missions of these programs. Innovation funding, therefore, is an essential catalyst for bringing NASA's state-of-the-art technological research together with USGS ecological science. Our proposed project leverages USGS and NASA capabilities and takes advantage of rapidly-emerging innovations from the tech industry to develop a new device that will advance ecological knowledge. Our successful Phase 1 and 2 products demonstrate the effectiveness of the partnership between USGS and NASA and has resulted in significant advances towards developing our full MVP. Phase 3 development and testing would use additional Innovation Center funding to provide the necessary personnel and raw materials. Adapting consumer technology for wildlife tracking purposes will require manipulation of existing hardware and software to boost signal ranges and enable expanded use in the field. We will allocate requested funds toward new engineering and prototype testing to accomplish our objectives. Success from this project would dramatically improve our understanding of ecological community interactions, thus advancing our ability to conserve the Nation's resources.

Partner goals, contributions and expected technology transfer:

As federal science research agencies, both USGS and NASA have considerable interest in developing novel tools that can be used across the Nation to advance scientific understanding. Our USGS-NASA partnership takes advantage of NASA engineering and emerging technologies and to make advances in the size, utility and cost of wildlife tracking devices. We demonstrated the success of this partnership through our Phase 1 and 2 products, which include development of a working proof-of-concept satellite-GPS tag containing a novel antenna architecture, as well as prototype solar, peer-to-peer network tag. In workshops to demonstrate our Phase 1 and 2 prototypes, USGS researchers studying a wide range of species expressed enthusiasm for using these tools to study topics ranging from open ocean tracking to disease transmission. We propose to build upon previous success to conduct Phase 3, in which NASA will integrate Phase 1 and 2 tags into heterogeneous hybrid networks. This hybrid of close-range wireless transmission among animals and long-range satellite data transmission would be the first of its kind and would open the door to novel applications in wildlife tracking and conservation. We are working on new opportunities to partner with BOEM (J. Levenson) and NASA (A. Martinez) researchers developing a small satellite system for next generation data transmission. Our tags will be designed to integrate with this developing system to promote a complete next generation tracking system. We will continue to use an open hardware, open software approach to produce a broadly transferrable design that can be adopted, modified, and improved to foster additional innovations by private sector manufacturers, universities, and other government labs. The NASA-Ames Research Center (Frost, Kemp) will provide laboratory and "space shop" facilities, hardware and software engineering expertise. USGS will provide expertise on the ecology and marking of several avian and marine mammal taxa and will assist with overall design and testing of transmitter prototypes. This proposal supports multiple goals of the USGS Ecosystems Mission Strategy including: (iv) Developing tools and technologies to inform decision making about ecosystems, and (v) Applying science to enhance strategies for management, conservation, and restoration of ecosystems.

Personnel:

USGS PIs: Susan E. W. De La Cruz, San Francisco Bay Estuary Field Station, 505 Azuar Drive, Vallejo, CA 94592 sdelacruz@usgs.gov, (707) 562-2004; **Center name and location**: Western Ecological Research Center, Sacramento, California ; **Center Director**: A. Keith Miles, keith_miles@usgs.gov; **Center AO**: Tina Palmer, tpalmer@usgs.gov; **USGS collaborators**: Isa Woo, iwoo@usgs.gov; Mike Casazza, mike_casazza@usgs.gov; Cory Overton, coverton@usgs.gov; Josh Adams, josh_adams@usgs.gov; Joseph Tomoleoni, jtomoleoni@usgs.gov; Zachary Randell, randellz@oregonstate.edu **Technology Partners**: Chad R. Frost, Deputy Director, Engineering, NASA Ames Research Center, Moffett Field, CA 94035, chad@nasa.gov, (650) 604-1798; Dayne Kemp, Engineering and Integration, dayne.h.kemp@nasa.gov.

USSG Mission Area alignments:

Our proposal results would contribute towards the goals of the one or two following Mission Areas (check):

☒ Climate and Land Use Change ☒ Core Science Systems ☒ Ecosystems
☐ Energy and Minerals, and Environmental Health ☐ Natural Hazards ☐ Water

May we share your proposal with the Associate Directors for the Mission Areas you checked above?

☐ No ☒ Yes

Budget Summary

Category	Description	In-Kind Contributions	Request
Personnel: USGS WERC	2 PP support for USGS technician, field testing	5 PP WERC PIs wildlife and tracking expertise, field testing, meetings, documentation and outreach	$ 3,374
Personnel: NASA	6 PP Electrical Engineer; 3 PP Software Engineer; 3PP Mechanical Engineer	2 PP support for NASA PI engineering expertise	$ 93,626

Equipment and Supplies	Fabrication, COTs components	"Space shop" testing facilities	$ 10,000
Contracts	Antenna design		$ 20,000
Sub-total			$133, 626 (NASA) $ 3,374 (USGS)
Total	USGS Cost Center rate 25.795% ($870)	NASA funds through IA agreement, ($23,000)	$ 150,000

Commented [A1]: This needs to be adjusted based on actual NASA OH rate

FIGURES:

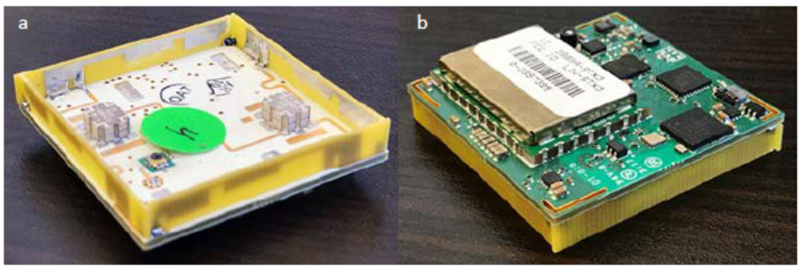


Figure 1. Prototype design for GPS-satellite tag showing (a) novel integrated antenna and (b) build-out of circuitry components. The build out is 20% lighter and 25% the cost of similar commercially available devices.

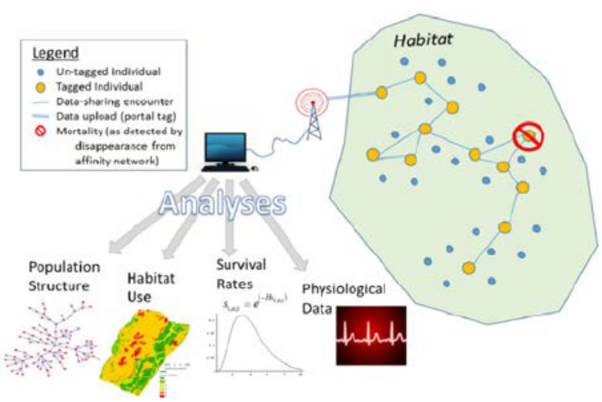
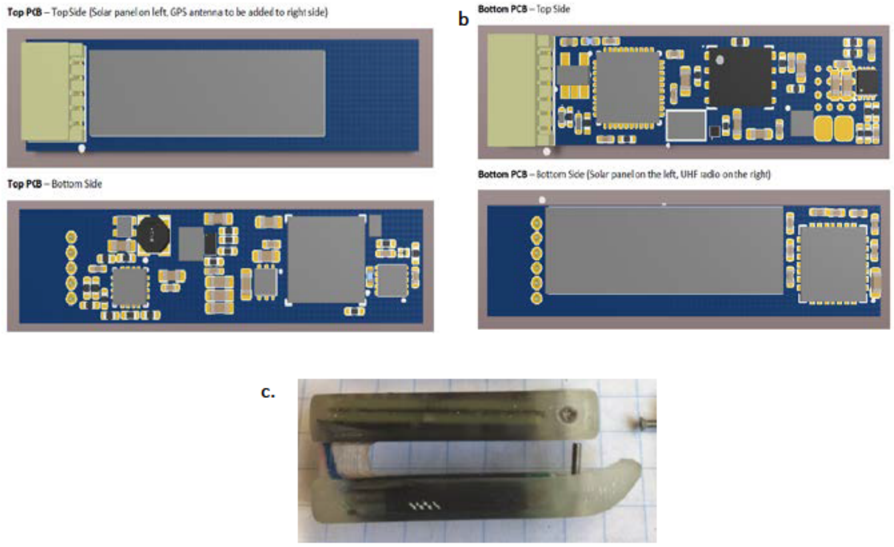


Figure 2. Conceptual model demonstrating capabilities of a peer-to-peer wildlife tracking network. Data are shared among individuals and uploaded from animals marked with portal tags. Analyses of location, sensor and interaction data advances our understanding of population structure, habitat use, survival, physiology and several other critical parameters.

a.

b



c.

Figure 3. (a) Top and (b) bottom conceptual design of Phase 2 prototype solar, peer-to-peer network tag designed for a (c) flipper or ear tag form factor.

Figure 4. Phase 3 projected timeline.

DEPARTMENT OF THE NAVY
THE ASSISTANT SECRETARY OF THE NAVY
(ENERGY, INSTALLATIONS AND ENVIRONMENT)
1000 NAVY PENTAGON
WASHINGTON DC 20350-1000

December 12, 2016

MEMORANDUM FOR CHIEF OF NAVAL OPERATIONS

SUBJECT: Southern Sea Otter Military Readiness Area Monitoring Plan

Reference: (a) National Defense Authorization Act for Fiscal Year 2016
(b) Endangered Species Act of 1973 (16 U.S.C. 1531 et seq.)
(c) Marine Mammal Protection Act of 1972 (16 U.S.C. 1361 et seq.)
(d) ASN (EI&E) memo to CNO of 13 Apr 2016
(e) USFWS ltr 08EVEN00-2017-B-0020 of 23 Nov 2017

Enclosure: (1) Monitoring and Research Plan for Southern Sea Otter Military Readiness Areas

The proposed Monitoring and Research Plan for Southern Sea Otter Military Readiness Areas, outlined in enclosure (1) is approved.

Background. Section 312 of reference (a), directed the Secretary of the Navy to establish Southern Sea Otter Military Readiness Areas (Sea Otter Areas). Within these designated Sea Otter Military Readiness Areas, Sections 4 and 9 of reference (b) and Sections 101 and 102 of reference (c) shall not apply to incidental takings of any southern sea otters in the course of conducting a military readiness activity.

Reference (d), assigned management, operation and reporting for Southern Sea Otter Military Readiness Areas to the United States Navy and fulfills the requirement to develop monitoring and research parameters and methods in consultation with the United States Fish and Wildlife Service (USFWS).

If you have any questions, my point of contact for this matter is Mr. John Pierson at 703-693-1785, john.c.pierson@navy.mil.

Dennis V. McGinn

cc:
Assistant Secretaries of the Navy
General Counsel of the Navy
DON Assistant for Administration

Monitoring and Research Plan for Southern Sea Otter Military Readiness Areas

U.S. Navy and U.S. Fish and Wildlife Service
in coordination with
U.S. Geological Survey

I. INTRODUCTION

The National Defense Authorization Act for Fiscal Year 2016 (NDAA) includes provisions directing the Secretary of the Navy to establish Southern Sea Otter Military Readiness Areas (Areas) at San Nicolas Island and San Clemente Island (Figure 1). Military readiness activities[1] conducted within these Areas are subject to certain exemptions under the Endangered Species Act of 1973, as amended (ESA) and Marine Mammal Protection Act of 1972 (MMPA). Specifically, with respect to the ESA, Sections 4 and 9 do not apply to the incidental taking of any southern sea otter in the Areas in the course of conducting a military readiness activity, and any sea otter within the Areas is to be treated for the purposes of section 7 as a member of a species that is proposed to be listed as endangered or threatened under the ESA. With respect to the MMPA, Sections 101 and 102 do not apply with respect to the incidental taking of any sea otter in the Areas in the course of conducting a military readiness activity.

The NDAA also specifies monitoring requirements for these Areas:

(1) IN GENERAL.—The Secretary of the Navy shall conduct monitoring and research within the Southern Sea Otter Military Readiness Areas to determine the effects of military readiness activities on the growth or decline of the southern sea otter population and on the nearshore ecosystem. Monitoring and research parameters and methods shall be determined in consultation with the U.S. Fish and Wildlife Service (USFWS).
(2) REPORTS.—Not later than 24 months after the date of the enactment of this section and every three years thereafter, the Secretary of the Navy shall report to Congress and the public on monitoring undertaken pursuant to paragraph (1).

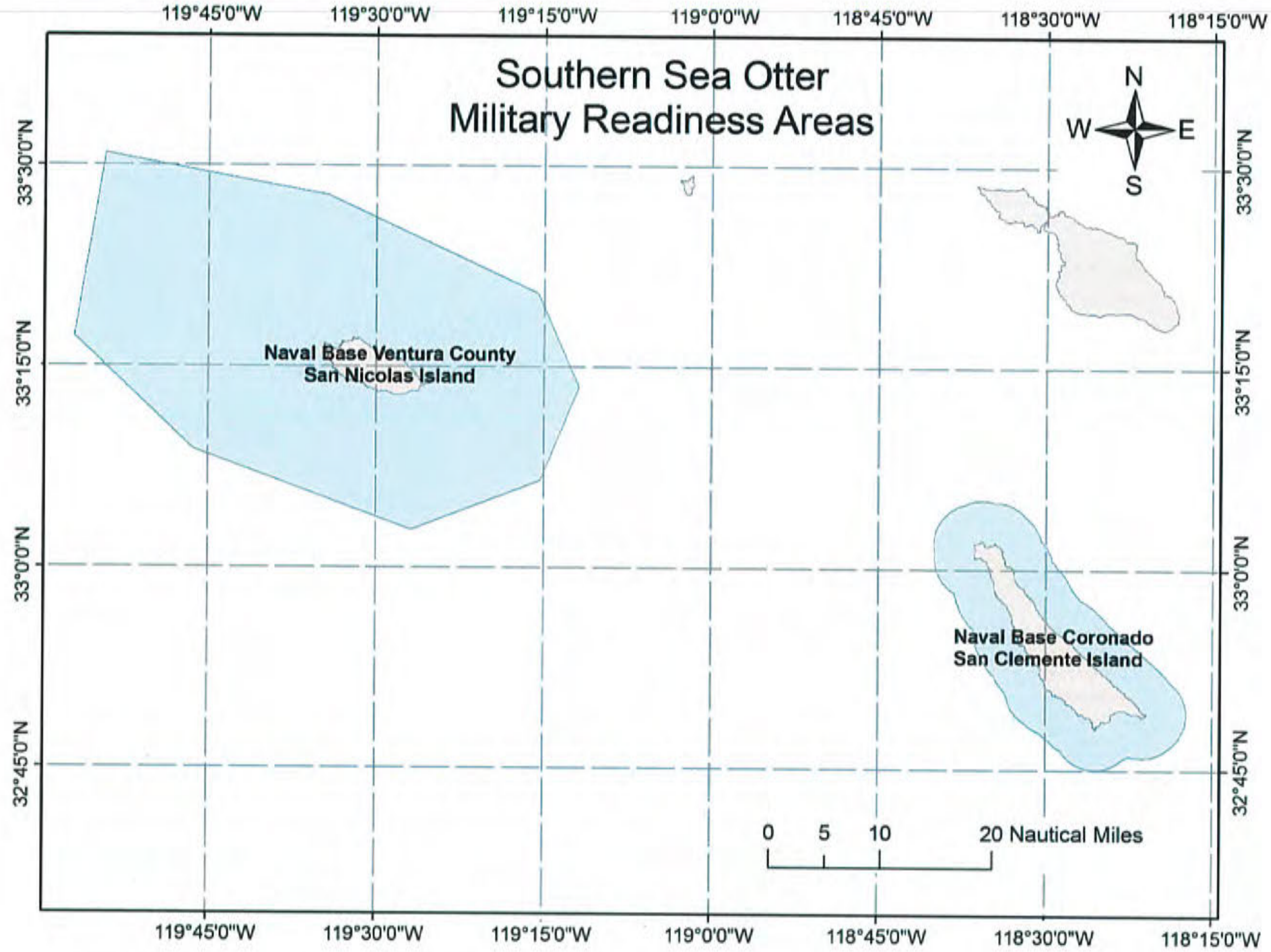
This document contains the research and monitoring plan for the San Nicolas Island Military Readiness Area (SNI Area). Required research and monitoring in this plan are tiered, using population status (increasing, stable, or decreasing) and changes in military readiness activities as triggers for the level of research and monitoring proposed.

Because sea otters do not yet occur at San Clemente Island and may not occur there for decades, preparation of a monitoring plan for the San Clemente Island Military Readiness Area (SCI Area) will not occur until at least three sea otters are present for at least twelve consecutive months or at least one female with a pup is detected. Marine and nearshore natural resource studies and monitoring activities currently occur in the areas around SCI to monitor for other species and habitats of concern. These studies and monitoring events will suffice to detect the presence and persistence of sea otters should they occur in the SCI Area in order to inform at what point a monitoring program under the law will be triggered. This document will be

[1] According to the NDAA, "The term 'military readiness activity' has the meaning given that term in section 315(f) of the Bob Stump National Defense Authorization Act for Fiscal Year 2003 (16 U.S.C. 703 note) and includes all training and operations of the armed forces that relate to combat and the adequate and realistic testing of military equipment, vehicles, weapons, and sensors for proper operation and suitability for combat use."

reviewed by Navy and USFWS every three years after completion of reports to ensure the plan continues to adequately monitor interactions between military readiness activities and the sea otter population.

Figure 1. Southern Sea Otter Military Readiness Areas.



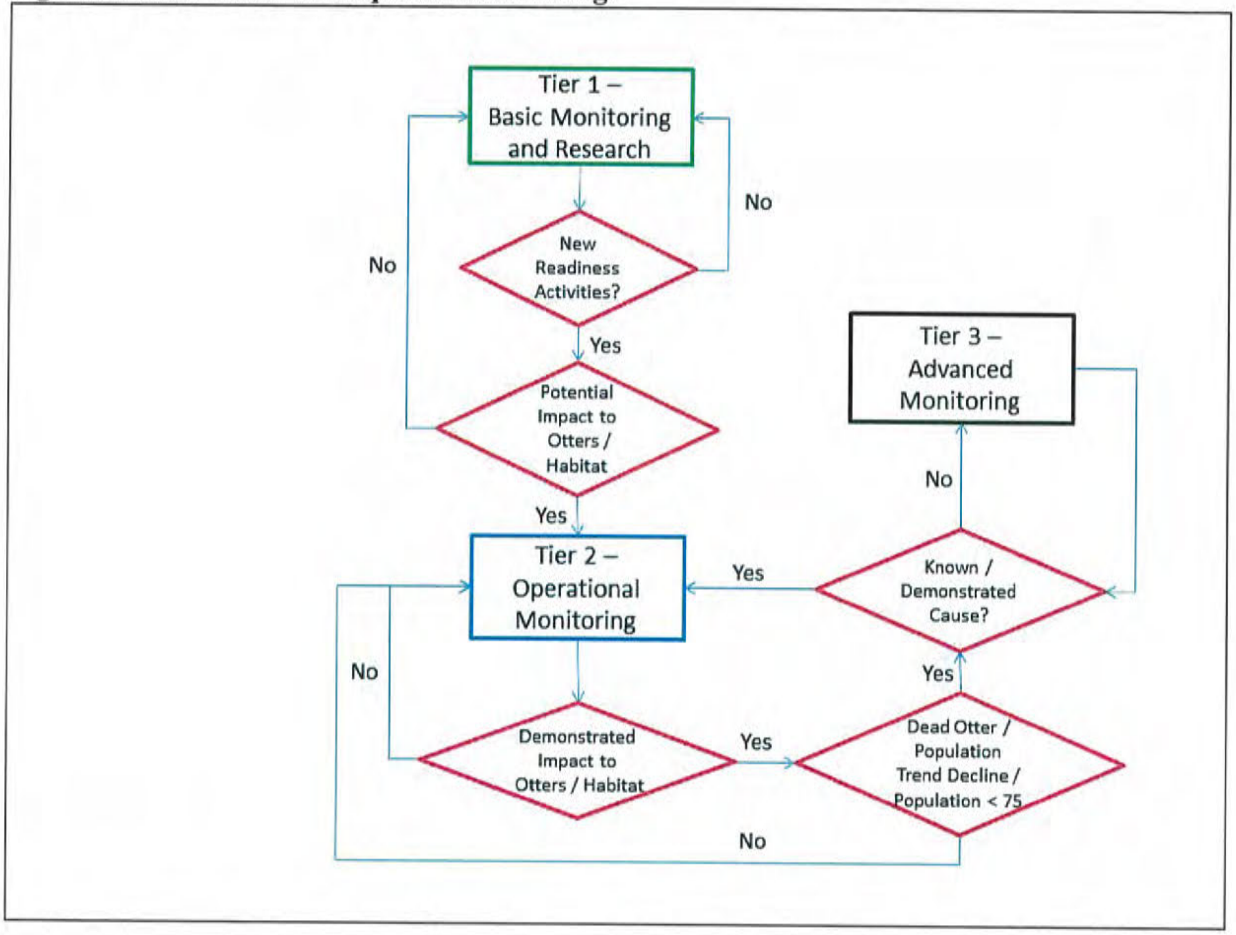
II. MONITORING AND RESEARCH PLAN FOR THE SNI AREA

The monitoring plan outlined below and in Figure 2 contains three tiers. The first tier is Basic Monitoring, which represents monitoring and research required given the current status of the sea otter population and currently occurring military readiness activities. Tier 1 efforts will continue as long as military readiness activities remain constant. The second tier is Operational Impact Monitoring. This higher level of monitoring would be required for any new military readiness activity[2] with a potential to impact sea otters or sea otter habitat. The third tier is Advanced

[2] For the purposes of this plan, a new activity is any activity that would require preparation of an Environmental Assessment or Environmental Impact Statement under NEPA with an area of potential effect within sea otter habitat. Existing activities are described in current NEPA documentation (Appendix 1).

Monitoring, which is triggered if new military readiness activities, as described in Tier 2, are occurring and any of the following conditions is also met: (1) a single dead, moribund, or stranded sea otter with injuries consistent with impacts from the activity (as determined by an independent pathologist) is detected; (2) the sea otter population trend at SNI decreases by more than 10% from the average SNI sea otter population trend over the preceding three-year period[3] for at least two consecutive years for reasons that cannot be reasonably attributed to anticipated density-dependent reductions in growth (see Tier 1, objective 3); or (3) the total sea otter population at SNI drops below 75. If additional funding or outside partnerships allow, Tier 2 and Tier 3 monitoring may occur even if military readiness activities and sea otter population trends remain stable.

Figure 2. Flow Chart of Required Monitoring.



[3] A 10% decrease in population trend would be determined after correcting for observer or measurement error, using State-Space model analysis of the survey time series or comparable method. Using the current average annual population increase of 1.1, for example, a 10% decrease would lead to no increase in population between years (rate of 1.0).

a. Tier 1 Basic Monitoring and Research

1. Objectives for Tier 1 monitoring

The overarching monitoring goal articulated in the NDAA (to determine the effects of military readiness activities on the growth or decline of the southern sea otter population and on the nearshore ecosystem) can be split into four specific objectives that, taken together, will ensure that this broader goal is achieved. These Objectives are:

1. *Monitor and analyze population trends at San Nicolas Island.* Data on trends in sea otter abundance are necessary to assess effects of various stressors on the population. In addition to conducting regular surveys, data will be analyzed using dynamical demographic models to infer baseline population parameters (i.e., annual growth rates and environmental variability). Such data are necessary but not sufficient on their own to determine *causes* of population trends.
2. *Monitor and analyze subtidal benthic communities and assess impacts of sea otter recovery on food web dynamics.* Another core dataset necessary for evaluating impacts on nearshore ecosystem health (with respect to sea otter populations) is monitoring data on benthic subtidal communities, including trends in abundance of foundational species such as kelp and key invertebrates such as urchins and abalone. These data should be analyzed using dynamical multi-species food web models in order to interpret the interacting effects of bottom-up forces (e.g., temperature, wave events) and top-down forces (e.g., increasing predation from sea otters).
3. *Determine the factors affecting population change. Specifically, assess the relative contributions of density-dependent factors (changes in per-capita prey abundance) and density-independent factors (e.g., shark mortality, military readiness activities) to variation in growth rates.* Extensive research on sea otter populations in California has demonstrated that the most common factor leading to localized reductions in population growth is density-dependent resource limitation. The rate of growth of a local population is generally high at low population densities (as has been the case at San Nicolas over the past 20 years) but will slow as populations approach local carrying capacity. The ultimate factor limiting growth is per-capita prey abundance, although resource-limitation may be manifested as increased mortality due to disease and emaciation. Therefore, in order to assess whether some other putative threat is influencing population trends at a given location (e.g., shark bite mortality, entanglement in fishing gear, contaminant exposure, etc.), it is necessary first to account for the role of density-dependent factors. Sea otters are almost unique among marine mammals, in that it is possible to accurately infer population status from a number of easily measured indices, including behavioral parameters (foraging success, percent time feeding), individual body condition, and direct measurements of the abundance and size distribution of key prey species, such as sea urchins. By tracking these indices over time, it has been possible in central California to determine the causal role of density-dependent resource limitation in slowing population growth, and this determination should be even more feasible at San Nicolas due to the existence of better baseline data sets. Achieving this objective will be critical for making a meaningful assessment of the effects of other factors on population growth, including military readiness activities.

4. *Describe habitat use by sea otters at San Nicolas and identify habitats necessary for vulnerable life history stages and behaviors.* Sea otters typically exhibit highly localized patterns of habitat use, which can vary by activity type and by demographic group. For example, resting activity generally occurs in dense kelp canopies, though not all kelp beds are used equally, and certain kelp beds are highly preferred by certain demographic groups (sub-adult males, or females with pups). In contrast, foraging activity more typically occurs along the outer margins of kelp beds and off of emergent rocks. Furthermore, the limited home ranges of most sea otters means that habitat utilization can vary at the scale of kilometers. Understanding home range and habitat use patterns is therefore critical for determining which specific areas around San Nicolas may be most sensitive in terms of the potential for military readiness activities to affect sea otter behavior or health. For example, an area used as resting habitat by reproductive females will be far more sensitive (in terms of the potential to affect population growth) than areas used for feeding by males.

2. Proposed Study Plan for Tier 1 Monitoring

To achieve the above four objectives, a multi-faceted approach consisting of the following tasks is proposed:

Task 1, Objectives 1 and 4. Population Surveys (All Years). An effective survey program for monitoring trends in sea otter abundance at San Nicolas Island is already in place: since the late 1980s, the USGS has annually conducted between two and four island-wide exhaustive sea otter counts, which are compiled in a GIS-compliant data set on abundance and distribution (see Tinker and Hatfield 2015). Surveys are currently conducted twice per year (spring and fall) to provide key data on trends in total abundance and also distribution of sea otters around the island. The frequency of these island-wide surveys would be increased to four times per year for the next four years to provide a higher resolution data set on seasonal variation in distribution and habitat use. These surveys would also provide initial data on important habitat areas around SNI. After four years, power analysis of the existing data can be performed to determine whether reduced effort at two surveys per year will be sufficient for accurate estimation of trends and achievement of other objectives (see Tasks 2 through 4).

Task 2, Objectives 2 and 3. Ecosystem Monitoring (All Years). As with Task 1, subtidal monitoring and kelp canopy monitoring programs are already in place, with twice-annual subtidal surveys conducted by USGS for the past 35+ years (Kenner et al., 2013) and annual kelp canopy surveys conducted by the Navy. For USGS subtidal monitoring, data on the relative abundance of benthic invertebrates, kelps, and fish are collected from seven permanent subtidal sites using standardized SCUBA methods. The resulting data set represents one of the most comprehensive and long-term time series on subtidal ecosystem dynamics worldwide. It can be used to infer the effects of physical disturbance (e.g., large wave events or El Niño conditions) and food-web perturbations (e.g., the recovery of sea otters, disease outbreaks) on community structure and dynamics. For Navy kelp canopy monitoring, multi-spectral kelp canopy images are collected annually via aircraft overflight, processed to determine both surface and subsurface kelp canopy to a 30 cm resolution, and input into a GIS dataset. Subtidal monitoring surveys and kelp canopy overflights would continue at the current frequency.

Task 3, Objectives 3 and 4. Collection of Foraging Data from Untagged Sea Otters (Years 1-2). A number of key indices for determining the population status of sea otters can be assessed from observational data on sea otter feeding. As food resources become more limiting, sea otter diets become more diverse at the population level and more specialized at the individual level, and the average rate of energy gain decreases (Tinker et al., 2008(b), 2012). Two of these indices (diet diversity and rate of energy gain) can be measured using standardized methods for collecting feeding data from untagged sea otters following previously established protocols (Tinker et al., 2008(b)). Earlier studies of sea otter diet and foraging behavior (1987-93, 2004-07), can be compared with current data to determine how sea otter prey choice and foraging success have changed over the last decade. These data will provide one important step towards achieving *Objective 3* and will also allow us to collect baseline data on sea otter distribution, behavior, and habitat use (*Objective 4*). They will also be invaluable for planning future capture and tagging operations, if needed (refer to Tier 3). Foraging data collection will occur concurrently with regular surveys for distribution and abundance (*Task 1*).

Task 4. Data Integration, Analysis, and Reporting (All Years). All field data collected will be entered in a geo-referenced Access database. Population dynamics will be analyzed using published methods to model sea otter populations (Clark and Bjørnstad, 2004; Tinker, 2015; Tinker et al., 2006). Data on sea otter locations and habitat use will be analyzed in GIS using spatial tools and compared with ecosystem and habitat data. Statistical analysis may include logistical regression (habitat use vs availability), Maximum Entropy Models and General Additive Model (GAM). A series of high resolution GIS digital maps will be created to summarize all spatial data and analysis results and to facilitate identification of important habitats for sea otters (habitats most frequently used for feeding and resting).

To evaluate ecosystem-effects of sea otter populations at San Nicolas Island (*Objective 2*), an existing Ecopath mass-balance food web model for sea otters and kelp forests will be modified by combining the dietary data collected during this project and the concurrent subtidal monitoring data (see Kenner et al., 2013), and projections of food web dynamics in response to sea otter predation will be conducted using Ecopath/Ecosim. Community interaction matrix approaches will be used to analyze and forecast food web dynamics. Both approaches will allow us to estimate the range and magnitude of ecosystem services associated with the recovery of sea otters.

b. <u>Tier 2 Operational Monitoring</u>

1. Objective for Tier 2 Monitoring

Operational monitoring under Tier 2 would be required for any new military readiness activity with a potential to impact sea otters or sea otter habitat. At present there are no proposed new military readiness activities with potential to impact sea otters or sea otter habitat and there are no data suggesting continuing activities demonstrate significant disturbance effects. Furthermore, the existence of a measurable disturbance effect would not by itself imply an impact on population growth (indeed, the relatively rapid rate of population growth at San Nicolas Island compared to the mainland population over the past 20 years would suggest that there have been minimal or no effects of disturbance on sea otter populations to date). Rather, the benefit of examining this question would be to provide useful data on the types of disturbance that elicit a response and the contexts in which effects on behavior or energy expenditure are most likely to

occur. Such information could be useful for planning purposes in future military readiness activities and for identifying potential problems before they occur.

1. *Assess the effects of disturbance on behavior and energetics.* In order to determine whether new military readiness activities have the potential to affect sea otter populations, it will be helpful to elucidate the likely mechanisms by which such an effect would occur. Specifically, certain types of activities may elicit a behavioral response (disturbance) and possibly impact individual energy expenditure (depending on the magnitude of response to the disturbance).

2. Proposed Study Plan for Tier 2 Monitoring

To achieve this objective, the following task is proposed for new military readiness activities at SNI with a potential to impact sea otters or sea otter habitat:

Task 1. Real-time Monitoring of Sea Otter Reactions. For any new military readiness activity with a potential to impact sea otter behavior, real-time monitoring of sea otter responses to the activity will occur. To detect behavioral responses and distinguish these from background levels of activity, a "Before-After-Control-Impact" (BACI) design will be used. The BACI experimental design requires sampling to be conducted at both control sites and "impact" (treatment) sites at repeated intervals before and during/after the activities in question. Behavioral sampling will be conducted using one of three methods: (1) If possible, sea otters will be monitored by Navy biologists using high-power telescopes from shore, after receiving training from USGS biologists in standardized scan-sampling methods for measuring the behavior of sea otters. Training will cover basic scan sampling protocols and the categorization of behaviors using standard sea otter ethograms. Note that direct monitoring can occur only if sea otters are present in areas visible by telescope and outside hazard patterns that preclude human presence; (2) Unmanned aerial vehicles (UAVs) may be used to observe sea otters either farther from shore or during events when hazard patterns preclude human presence. UAVs will be equipped with high-resolution video cameras that allow the observation of behavioral changes. In the case of this option, Navy personnel will work with USGS biologists to validate UAV data collection techniques via comparisons with data collected by human observers; (3) If in place, archival data logging tags described under Tier 3 monitoring would replace the previous two methods (see below).

c. <u>Tier 3 Advanced Monitoring</u>

1. Objective for Tier 3 Monitoring

Advanced monitoring would be required in the event that new military readiness activities as described in Tier 2 are occurring and any of the following conditions is also met: (1) a single dead, moribund, or stranded otter with injuries consistent with impacts from the activity (as determined by an independent pathologist) is detected; (2) the sea otter population trend at SNI decreases by more than 10% from the average trend over the preceding three-year period for at least two consecutive years for reasons that cannot be reasonably attributed to anticipated density-dependent reductions in growth (see Tier 1, objective 3); or (3) the total sea otter population at SNI drops below 75. This monitoring would focus on providing a more detailed analysis of habitat use, emigration (if occurring), and reactions to specific activities. If no substantial effect from military readiness activities on sea otter health is detected and a reason for

the declining growth trend is known (e.g., shark bite mortality or food limitation, as substantiated by other monitoring), Tier 3 monitoring would not be required.

After a second consecutive year of change by more than 10% from the current sea otter population trend following the occurrence of new military readiness activities, the Navy will secure funds as quickly as possible to initiate any advanced monitoring requirements. Advanced monitoring will begin when these new funds become available. Advanced monitoring may also benefit earlier objectives, as described, and will be supported prior to the Tier 3 trigger if additional funding or partnerships become available.

2. Proposed Study Plan for Tier 3 Monitoring

To achieve this objective, the following tasks are proposed:

Task 1. Capture, Tagging, and Sampling. In compliance with all applicable Federal laws and statues, a sample of approximately 25 sea otters at San Nicolas Island will be captured and tagged, following methods utilized for many similar studies in the past, including one conducted previously at San Nicolas Island (Tinker et al., 2008(a)). Captures are conducted by a highly experienced and uniquely trained sea otter capture team using specialized closed-circuit SCUBA methods (Ames et al., 1983). Divers swim out from small skiffs, guided by radio transmissions form the skiff operator and shore-spotters, and position underneath a potential resting sea otter. The divers then swim upwards and entrap the resting animal in a Wilson trap attached to an underwater propulsion device. The captured animals are then transported back to a support vessel for processing by a veterinary team.

All captured animals will be anaesthetized and tagged and will receive comprehensive health exams and bio-sampling. Each animal is equipped with colored flipper tags for visual identification, a surgically implanted VHF transmitter for radio tracking, and a time-depth recorder (TDR) for bio-logging of diving activity. VHF frequencies will be deconflicted with Navy working frequencies to avoid any mission impact. Analysis of morphometric data and health parameters, and comparison of these with other sub-populations in California and with previously captured animals at San Nicolas Island (2005-07), will also contribute towards accomplishing Tier 1, *Objective 3*.

Task 2. Telemetry-based Monitoring of Tagged Animals (2Years). After release, study animals will be monitored regularly (using standardized VHF telemetry protocols) by shore-based observers. This phase will continue for two years past tagging (pending support for follow-on work). Field personnel will conduct shore-based daily surveys of the study site using standard telemetric protocols (triangulation on radio signal using VHF telemetry receivers and visual identification using 50-80X Questar spotting scopes: see Tinker et al., 2006, 2008) to locate all study animals within the study area and record precise GPS position, survival, reproductive status, and instantaneous behavior. Attempts will be made to re-sight all study animals at least five times per week. A series of intensive focal-animal observation sessions will be established to collect detailed behavioral data. During these 12-hour focal animal monitoring sessions, data will be recorded at 10-minute intervals on the individual's activity state, diet, dive behavior, distance-to-shore and fine-scale movements (habitat use). Whenever study animals feed during these activity sessions, continuous data will be recorded on dive/surface intervals and prey capture rates and handling times following previously established protocols (Tinker et al., 2008(b)). The anticipated schedule of focal-animal observation sessions is two sessions per

week, with a goal of obtaining three sessions for each study animal. These data, and comparisons with similar data from other populations, provide additional information for characterizing habitat use patterns (Tier 1, *Objective 4*), foraging success and status with respect to prey resources (Tier 1, *Objective 3*), and predator-prey interactions and ecosystem impacts (Tier 1, *Objective 2*).

Task 3. TDR Retrieval and Analysis. After two years of deployment, a second capture operation will recapture previously tagged otters. Recaptured animals will undergo another surgery in order to retrieve the implanted TDR (containing two years of bio-logged diving and temperature data), and a second set of morphometric and bio-health samples will be collected. *Note that at this time a subcutaneous networking tag programmed for short-distance communications and data sharing between otters (and between otters and a buoy equipped with a data retrieval unit) would be implanted.* Data from the retrieved TDR units will be downloaded and analyzed, following established methods, in order to obtain detailed information on time-activity budgets, foraging behavior and diving depth, and reproductive parameters, thereby contributing to Tier 1, *Objectives 3 and 4*. Because the data on behavior have a high resolution (2-second interval between depth readings), it will be possible to relate changes in activity to specific events that occurred over the two-year period, thereby contributing to the Tier 2 objective of identifying reactions to specific events. Existing Navy data on operational dates and times will be used to cross-reference with TDR data.

III. TENTATIVE BUDGETS[4]

Note: The Navy will provide funding for all costs described below. The following budget is divided into expenses associated with implementing Tier 1, 2 and 3. Existing funding for activities already underway is included within Tier 1 expenses (grey highlight).

Tier 1 Budget

Tier 1 Budget Category	Budget Line Item	FY16 Budget Amount	FY17[1] Budget Amount	FY18 Budget Amount	FY19 Budget Amount
USFWS					
Salary	SSO Recovery Coordinator--up to 4 5-day trips/year for data collection w/USGS personnel ($68/hour x 8 hr x 5 days)[1]	$2,732	$10,928	$10,928	$10,928
Travel	Field travel to-from field site plus per diem expenses ($1000/trip)[1]	$1,000	$4,000	$4,000	$4,000
	USFW Sub-total	$3,732	$14,928	$14,928	$14,928
	Indirect Costs @ 22%	$821	$3,284	$3,284	$3,284
	USFWS Total	**$4,553**	**$18,212**	**$18,212**	**$18,212**
USGS					
Salary	Principal Investigator – to oversee project, study design, conduct analyses, finalize reports ($109/hour for 80 hours each year)	$8,720	$8,720	$8,720	$8,720
Salary	Researcher/Project Biologist – to oversee field research and documentation, assist with analysis, and develop reports ($55/hour for 120 hours year 1 and 360 hours years 2 to 4)	$6,600	$19,800	$19,800	$19,800
Salary	Two Research Assistants to support and assist the Project Biologist ($27/hour for 60 hours year 1, 320 hours years 2 to 4)	$1,620	$8,640	$8,640	$8,640
Salary	Additional support for research biologist or graduate sudent to asssist with Food web model development	n/a	n/a	$12,000	$12,000
Materials/ Supplies	Miscellaneous Supplies for sea otter montiroing	$2,000	$1,000	$1,000	$1,000
Travel	Field travel for personnel to-from field site plus per-diem expenses, 3 personnel for 4 data collection field trips of 5 days each	$2,000	$8,000	$8,000	$8,000
Subtidal	Support for Charters, UCSC salary and miscellaneous supplies associated with Subtidal Monitoring, $60K per year[2]	$39,475	$39,475	$39,475	$39,475
	USGS Sub-total	$60,415	$85,635	$97,635	$97,635
	Indirect Costs @ 52%	$31,416	$44,530	$50,770	$50,770
	USGS Total	**$91,831**	**$130,165**	**$148,405**	**$148,405**
USN					
Kelp Canopy	Support for aerial kelp canopy imagery collection and GIS layer compilation[3]	$9,497	$9,677	$9,874	$10,088
	USN Total	**$9,497**	**$9,677**	**$9,874**	**$10,088**
	Tier 1 Total	**$105,881**	**$158,055**	**$176,492**	**$176,705**

[1] Typical involvement is expected to be 1-2 trips/year. FY 16 lower in several areas due to partial year funding. Excess funds will be returned to the Navy.
[2] Current funding of $60 K per year provided by NAVFAC to USGS.
[3] Current funding of $10 K per year provided by NAVAIR contract.

[4] No provision of this plan shall be interpreted as constituting a commitment or requirement that the United States is obligated to pay funds in contravention of the Anti-Deficiency Act, 31 U.S.C. § 1341, or any other provision of law.

Tier 2 Budget

Tier 2 Budget Category	Budget Line Item	FY 1 Budget Amount	FY 2 Budget Amount	FY 3 Budget Amount	FY 4 Budget Amount
Salary	Principal Investigator – to oversee project, study design, conduct analyses, finalize reports ($109/hour for 40 hours each year)	n/a	$4,360	$4,360	$4,360
Salary	Researcher/Project Biologist – to oversee field research and documentation, train and collaborate with Navy biologists, ($55/hour for 80 hours years 2 to 4)	n/a	$4,400	$4,400	$4,400
	Sub-total		$8,760	$8,760	$8,760
	Indirect Costs @ 52%		$4,555	$4,555	$4,555
	Tier 2 Total		$13,315	$13,315	$13,315

Tier 3 Budget

Tier 3 Budget Category	Budget Line Item	FY 1 Budget Amount	FY 2 Budget Amount	FY 3 Budget Amount	FY 4 Budget Amount
Salary	Principal Investigator – to oversee project, study design, conduct analyses, finalize reports ($109/hour for 40 hours years 2 to 4)	n/a	$4,360	$4,360	$4,360
Salary	Researcher/Project Biologist – to oversee field research and documentation, assist PI with analysis, develop reports (55/hour for 1200 hours years 2 to 4)	n/a	$66,000	$66,000	$66,000
Salary	Research Assistant to support and assist the Project Biologist ($27/hour for 1200 hours years 2 to 4)	n/a	$32,400	$32,400	$32,400
Vessel Charter	Support Vessel for Capture operations	n/a	$35,000	n/a	$35,000
Travel	Field travel for personnel to-from captures, plus per-diem expenses	n/a	$10,000	n/a	$10,000
Travel	Field travel for personnel to-from field site plus per-diem expenses	n/a	$25,160	$25,160	$25,160
Equipment	2 VHF tracking receiver	n/a	$2,000	n/a	n/a
Equipment	2 Field Handheld computers for Data Collection	n/a	$2,000	n/a	n/a
Equipment	1 Laptop Computer, data entry	n/a	$2,000	n/a	n/a
Equipment	Buoy/receiver for recording otter network data	n/a	$2,000	n/a	n/a
Materials/ Supplies	Surgical and sampling supplies @ $800 each	n/a	$20,000	n/a	$20,000
Materials/ Supplies	VHF Telemetry tags @ $1000 each	n/a	$25,000	n/a	n/a
Materials/ Supplies	Time Depth Recorders, 15 @ $1200 each	n/a	$18,000	n/a	n/a
Materials/ Supplies	Miscellaneous Supplies	n/a	$5,000	$2,000	$2,000
	Sub-total		$248,920	$129,920	$194,920
	Indirect Costs @ 52%		$129,439	$67,558	$101,358
	Tier 3 Total		$378,359	$197,478	$296,278
	Grand Total - All Tiers	$105,881	$549,729	$387,285	$486,298

IV. LITERATURE CITED

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Appendix 1
List of Current Navy NEPA documents
San Nicolas Island

Document Title	Date	Brief Description
Environmental Assessment Directed Energy Test Facilities at San Nicolas Island	2015 Jun	Directed Energy test facility construction and operations
Environmental Assessment/Overseas Environmental Assessment Point Mugu Sea Range Expansion of Unmanned Systems Operations	2015 Feb	Increased use of both unmanned aerial vehicles and unmanned surface vehicles on the Sea Range
Environmental Assessment Point Mugu Sea Range Countermeasures	2014 Jul	Use of various countermeasures, including guns, directed energy, chaff, flares, and others on the Sea Range
Final Environmental Assessment for Obtaining California Sea Lions for Service in the Navy Marine Mammal Program	2012 Dec	Collection of live sea lions from San Nicolas Island
Final Environmental Assessment/Overseas Environmental Assessment Laser Testing and Training Naval Air Warfare Center Weapons Division Sea Range, Point Mugu, California	2010 Jun	Testing and training with lasers at Point Mugu and San Nicolas Island
Final Environmental Assessment SSM-1 KAI Missile Testing at San Nicolas Island	2007 Mar	Testing and training with Japanese Defense Forces missile system
Environmental Assessment FOCUS Cable Repair – San Nicolas Island, CA	2003 Sep	Repair of undersea fiber optic cable
Arrow System Improvement Program Environmental Assessment	2003 Nov	Testing and training with Israeli Defense Forces missile system
Final Environmental Impact Statement/Overseas Environmental Impact Statement Point Mugu Sea Range	2002 March	Programmatic coverage for Sea Range testing and training activities
Construction and Operation of a Supply Pier on San Nicolas Island	2002 Sep	Pier constructions at San Nicolas Island
Final Environmental Assessment/Overseas Environmental Assessment Harpoon BLOCK II Development Test 2 on the Point Mugu Sea Range	2001 Dec	Testing and training with Harpoon missile systems on Sea Range
Addendum to the EA for Tomahawk Flight Test Operations on the West Coast of the United States	2000 Nov	Addition of a soft-landing area on San Nicolas Island for Tomahawk missile system testing and training.
Final Environmental Assessment - Tomahawk Flight Test Operations on the	1998 Oct	Testing and training with Tomahawk missile systems on

Document Title	Date	Brief Description
West Coast of the United States		the Sea Range
Environmental Assessment Non-warhead Standoff Land Attack Missile (SLAM) Expanded Response (ER) Developmental Test & Evaluation Firings San Nicolas Island, Ventura County, California	1997 Oct	Construction and operation of an inert (non-warhead) target site on San Nicolas Island
Environmental Assessment of the Use of the Outer Sea Test Range for the Shock Trial of The DDG 53	1994 Apr	Shock trial for a specific Navy Destroyer
Environmental Assessment, Fiber Optic Communication Undersea System (Focus)	1989 Mar	Installation of an undersea fiber optic cable between Point Mugu and San Nicolas Island

PROJECT SUMMARY

Overview:

We propose to test for the hypothesized effects of predator diversity on the stability and resilience of kelp forest ecosystems in the face of an ongoing epidemic that has caused coast-wide losses of key sea star species. We will specifically examine the ability of southern sea otters (Enyhda lutris lutris) to compensate for declines in sea stars and use this opportunity to test hypothesized mechanisms by which predators do or do not collectively contribute to the control of herbivores (purple sea urchins and snails) that can otherwise cause phase shifts in kelp forest ecosystems.

Intellectual Merit :

This project will advance our understanding of the combined roles of species diversity and predators in contributing to the stability and resilience of community structure. Though both predators and diversity have been the focus of numerous studies, fewer have explored how predator diversity does or does not enhance the resilience of marine ecosystems. Specifically, elucidation of both the relative importance of direct (mortality) and indirect (prey behavior) trait-mediated effects of predators on prey density and foraging behavior, while simultaneously identifying the mechanisms (i.e. redundancy, complementarity) by which predator diversity determines the strength of this effect is critical to advancing our understanding of the roles of diversity and predation for ecosystem resilience. Dissecting these complex species interactions with unprecedented controlled field experiments to assess their causal relationships at scales relevant to real patch dynamics, combined with field surveys to evaluate their manifestation at scales of the whole ecosystem (kelp forests) collectively constitute the transformative potential of this research. By exploring these species interactions in kelp forest ecosystems, we capitalize on an extraordinary foundation of ecological understanding, hence the rationale for our focus on this system. In addition, the results of this study will inform our understanding of the ecological consequences and reasons for the extent and duration of ecosystem-wide impacts of the current sea star wasting event.

Broader Impacts :

The broader impacts of this study include three elements: graduate and undergraduate training, public outreach, and informing conservation managers and policy makers. Graduate training will be achieved through co-mentoring one graduate student funded directly by this award. To assist graduate students, faculty and researchers in all aspects of the study, we will recruit from a pool of undergraduates with a substantial portion of underrepresented, largely Latino, students. Our outreach efforts will have three main audiences: K-12, the general public, and marine resource managers. Our outreach efforts will target four unique opportunities. We will collaborate with the Monterey Bay Aquarium to facilitate disseminating information about the study and its results through their extensive outreach program, including a huge K-12 educational program. We will collaborate with UCSC?s Broader Impacts Office to pursue outreach avenues such as The Seymour Marine Discovery Center (http://seymourcenter.ucsc.edu/), which provides a conduit to K-12 programs and general public. We will co-develop a video presentation on the project with the Center?s display team. We will use a website and interactive map maintained by one of our associated investigators for tracking the incidence of sea star wasting. Management and policy institutions whose decisions and actions will benefit from the findings of this project include the United States Fish and Wildlife Service (US FWS), California?s Department of Fish and Wildlife (CDFW) and Ocean Science Trust, and federal agencies including The Monterey Bay National Marine Sanctuary (MBNMS), and the USGS Western Ecological Research Center.

Title: Kelp forest community resilience in action: adaptive responses of predators to a disease-driven food web perturbation

Background

Biological communities and the ecosystems they constitute can be remarkably stable, gradually change through time, or exhibit rapid and dramatic changes between markedly different structural and functional states. Explaining and predicting these dynamics are fundamental goals of ecology with great implications for conservation and management. The capacity to explain and predict system dynamics requires knowledge of the biotic and abiotic processes that determine community structure (i.e. species composition, richness and evenness), and functions (i.e. interactions among species and their environment that determine energy/nutrient dynamics). There are now many examples demonstrating how species interactions can have profound influences on the structure and functioning of marine communities and contribute to their resistance and resilience to biotic (e.g., harvesting, disease, invasion) and abiotic (e.g,, storms, El Nino, habitat loss, hypoxia) perturbations (*1–6*). Collectively, these studies emphasize the separate and substantial effects that higher level predators (*7–24*) and changes in biodiversity (*3*, *5*, *25–27*), can have on the structure, functioning and stability of marine communities. However, how diversity of key consumers influences the structural and functional attributes and the resistance and resilience of marine ecosystems is less well understood (*17*, *28*, *29*).

The role of biodiversity and mechanisms by which species and functional diversity imparts resistance and resilience and enhances ecosystem productivity has received great attention (*2–6*, *30–38*). Two mechanisms by which diversity enhances these ecosystem attributes are redundancy and complementarity (*39*). Redundancy occurs when species that contribute similar functional roles yet differ in their responses to environmental variation and perturbations, compensate for one another, thereby maintaining ecosystem functionality. Complementarity is the enhancement of one species' function by the presence of other species. Greater species diversity increases the likelihood that both of these mechanisms will be observed within a community, the so-called "sampling effect" (*40*). While these concepts identify mechanisms by which diversity and species interactions contribute to system resistance and resilience, their application for predicting system responses requires knowledge of the relative strengths of species interactions, how species interact and respond to changes in density, and how these interactions vary with different or changing environmental conditions and forms of perturbation (e.g., physical or biological).

Because of their great species richness, productivity and accessibility, kelp forests (laminariales) in temperate oceans throughout the world have attracted ecologists exploring how species interactions influence community and ecosystem dynamics. Kelp forests exhibit a diversity of dynamics, with some forests persisting for decades, others exhibiting strong interannual variability, and others demonstrating rapid shifts from forested to barren states that can persist for decades (*41–59*). Such dynamics also exist within forests, creating mosaics of asynchronous patches in various states of community structure (*41*, *43*, *44*, *46*, *55*, *60*). These dynamics are thought to reflect the combined effects of physical forces (ocean waves that remove portions or entire forests) and variation in grazing intensity associated with changes in the abundance and foraging behavior of sea urchins (*41*, *47*, *48*, *52*, *55*, *56*, *58*, *59*, *61–69*) reviewed in (*53*, *54*, *70*, *71*). The persistence of alternative states appears to be influenced by positive feedbacks; overgrazing by urchins both reinforces their intensive grazing behavior (*47*, *54*, *72*) and facilitates their own recruitment (*73*). In addition, grazing gastropods may contribute to mortality of gametophytes and sporophytes of kelps (*49*, *74*).

The vast majority of studies that have examined how species interactions influence the state of kelp forests suggest that specific higher-level predators can have marked influences on forest

dynamics (reviewed by (*54*, *71*, *75*). For example, studies of sea otters, *Enhydra lutris*, in kelp forests along the Aleutian archipelago (*76–80*) and Vancouver Island, Canada (*58*) revealed how trophic cascades generated by these apex predators can control the structure of these forest communities. When otter densities were reduced through human exploitation or orca predation, otters were unable to control the behavior and abundance of their prey, herbivorous urchins, allowing these systems to shift from forested to barren reefs (devoid of macroalgae) (Estes et al 1998). At smaller spatial scales, patchy distribution of the sunflower star, *Pycnopodia helianthoides*, in Alaskan forests create mosaics of forested and barren reef patches altering the structure and productivity of the system (*81*). California sheephead, *Semicossyphus pulcher*, are urchin predators in *Macrocystis* forests along the coasts of southern California and Mexico (*69*, *82–85*) and urchin density, size structure and foraging rates can be inversely related to sheephead density (*69*, *83*, *85*, *86*). Large size classes of spiny lobster can likewise control the density and size structure of urchins in *Macrocystis* forests of Tasmania. Where the size structure of lobster is reduced by commercial fishing, urchins achieve size refuge and forests are replaced by barrens (*87*). Similarly, in *Macrocystis* forests in southern California, the California spiny lobster (*Panuliris interruptus*) can be an important predator on purple and red sea urchins (*51*, *82*, *88*, *89*), though their effects appear to vary geographically (*90*, *91*). The extent to which the cascading effects of any one of these urchin predators determine the spatial and temporal variation in kelp abundance continues to be debated among ecologists. While these studies suggest the importance of individual predators in determining the dynamics, structure and functions of kelp forests, they also implicitly assume that loss of these species are not compensated for by alternate (functionally redundant) predators. Thus, while such predators are particularly vulnerable to natural and anthropogenic losses, the consequences of predator diversity in controlling grazing effects and contributing to the resistance and resilience of forest ecosystems remains poorly understood (*29*).

Predator diversity can influence the strength and direction of species interactions, including trophic cascades, by either dampening (*92*) or magnifying (*93*) their effects. For example, Byrnes et al (*93*) found that diversity (not density) of predators at lower trophic levels was negatively correlated with herbivore abundance and positively correlated with kelp abundance. These results were corroborated by mesocosm experiments and also revealed that predator effects involved behavioral responses of prey that dramatically altered their grazing rates. That study and others (*47*, *83*, *86*, *94*, *95*) lend evidence for strong indirect trait-mediated effects of predators in altering the distribution and foraging behavior of urchins and contributing to resistance and resilience of kelp forests. Indeed, the role of trait-mediated (especially behavioral) influences of predators may be a particularly important mechanism of trophic cascades (*96*, *97*). As such, and contrary to the majority of studies indicating the importance of particular predators, predator diversity may enhance the effect of each predator species in controlling grazers, because a more diverse suite of predators feeds more efficiently across all size classes of urchins (i.e. complementarity) or one predator can compensate for the loss of another (i.e. redundancy). Both of these mechanisms may involve direct (mortality) or indirect (foraging behavior) responses of their prey (urchins).

In central California, southern sea otters (*Enhydra lutris nereis*, hereafter “otters”) are important predators of sea urchins (*98*, *99*) and the almost ubiquitous low densities of urchins in this area is assumed to reflect their presence (*59*, *98*, *100*). Otters are voracious predators that consume 25-33 percent of their body weight per day (*101*) and whose diet includes urchins as well as a diverse array of benthic invertebrates (*98*, *102*). Although diet diversity is high at the population-level, individual otters in resource-limited areas tend to specialize on a just few prey types (*99*, *103*), and so urchins (when they are at low abundance) are mostly consumed by urchin specialists.

However, examples of marked changes in urchin abundance independent of otters also exist (*61*, *62*, *104*), and otter access to local (patch-scale) populations of urchins has never been manipulated to evaluate the rate and magnitude of mortality attributable to their predation. Another potentially important urchin predator in the central coast, the sunflower star (*Pycnopodia helianthoides*, hereafter *Pycnopodia*) feeds on smaller sea urchins and a diversity of herbivorous gastropods (e.g., *Promartynia pulligo*, hereafter *Promartynia* or snails) (*62*, *63*, *81*, *82*, *93*, *105*). Another particularly abundant carnivorous sea star, the giant sea star (*Pisaster giganteus*, hereafter *Pisaster*) forages on sessile and mobile invertebrates, including a diversity of carnivorous and herbivorous gastropods (*74*, *106*, *107*). However, over 1000 diet samples of *Pisaster* produced zero urchins (*108*), suggesting that influences of *Pisaster* on urchin foraging rates is more likely to be a predator avoidance response. Thus, understanding the separate and combined (additive or multiplicative) effects of these sea stars and otters in controlling urchin density and foraging behavior is central to understanding how predator diversity affects the resistance, resilience and productivity of kelp forest ecosystems.

In 2014, several species of intertidal and shallow subtidal sea stars experienced an epizootic (viral or bacterial disease) that has led to widespread declines in the abundance of several species of sea stars (*109*). Across the West Coast of North America from Alaska to Mexico, populations of intertidal (*Pisaster ochraceus*) and subtidal (especially *Pycnopodia* and *Pisaster giganteus*) sea stars have experienced local extinctions, including those species previously implicated as "keystone" predators that disproportionately influence the structure and functions of their ecosystems relative to their abundance (*81*, *110*, *111*). Already, densities of both purple, (*Strongylocentrotus purpuratus,* hereafter "purple urchins"), and red urchins (*S. franciscanus,* hereafter "red urchins"), have increased beyond typical densities (Figure

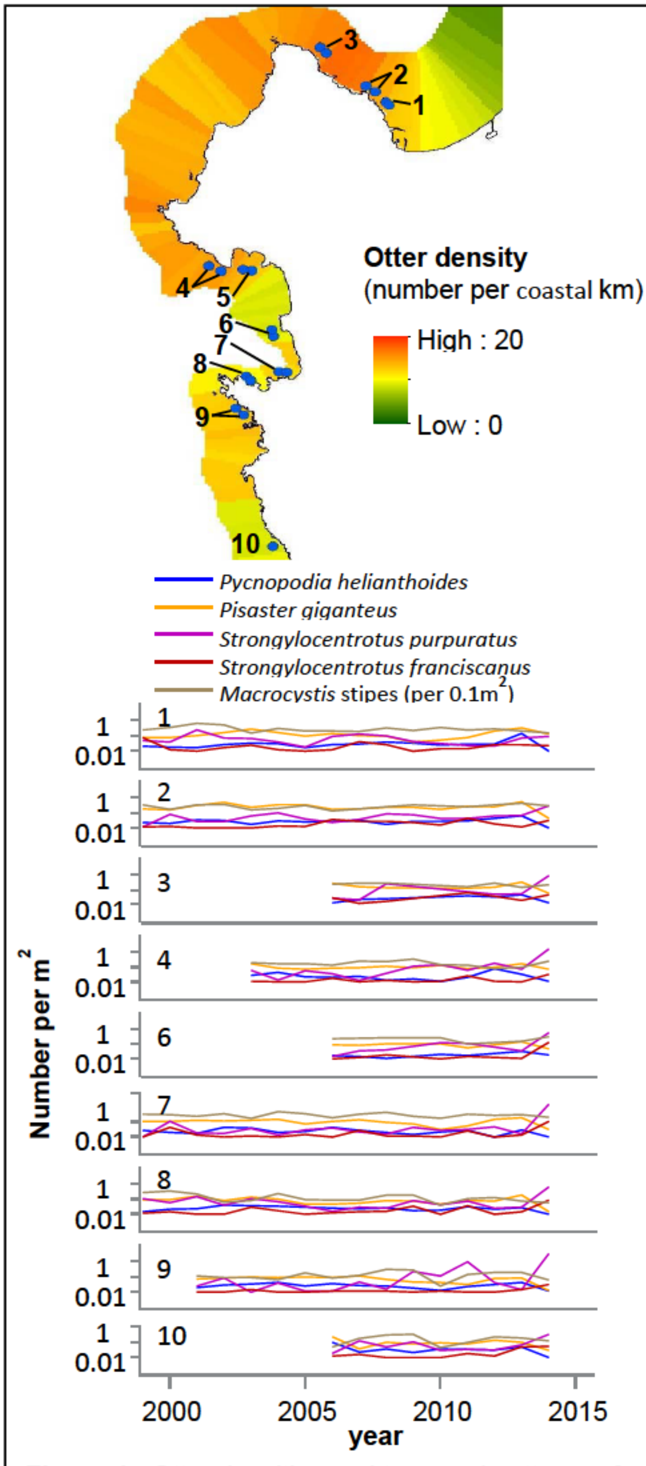

Figure 1. Otter densities and temporal patterns of sea star (*Pycnopodia helianthoides* and *Pisaster giganteus*), sea urchins (*Strongylocentrotus franciscanus* and *S. purpuratus*) and giant kelp (*Macrocystis*) stipes from sites surrounding the Monterey Peninsula during the period 1999-2014. Density estimates represent mean of 6-12 transects per site.

1). Over the 16 years and 10 sites surveyed around the Monterey Peninsula, annual change in density (log ratio of one year to the next) of purple urchins was inversely related to change in *Pisaster* and *Pycnopodia* (R^2=0.1144, P<0.0001 and R^2=0.0852, P<0.0001, respectively). In contrast, a weak relationship was detected between annual changes in density of red urchins and *Pisaster* (R^2=0.0313, P= 0.0303), and no relationship was detected between red urchins and *Pycnopodia* (R^2=0.0038 , P= 0.4529).

Although densities of giant kelp, *Macrocystis pyrifera,* have not yet decreased as predicted by the trophic cascades identified in the many examples summarized above (Figure 1), the occurrence of patchy barrens, rarely seen over the 15 year history of surveys conducted throughout central California kelp forests, have been noted (personal observations). Based on these observations and expected time lags in the dynamics of both urchins and kelps to declines in sea star predators, marked declines in kelp density and shifts from forested to barren reefs are predicted. As such, the current sea star epizootic presents a very unique and timely opportunity to explore whether and how the diversity of key urchin predators may buffer ecosystems to this perturbation.

Initial increases in recorded numbers of red and especially purple urchins across all size classes suggest that the apparent increase in densities reflect a trait-mediated behavioral response. As observed in the several studies described above, increases in densities of larger size classes implicate a shift in urchin behavior that has led to their greater detection on surveys (Figure 2). Rapid increases in the larger size classes of purple urchins observed in 2014 can't be explained by numerical responses (i.e. recruitment) or increased survivorship; numbers of larger purple urchins observed in 2014 exceed the sum of the that size class (100% survivorship) and then next three smaller size classes from the previous year (typical mean growth rates of purple urchins are roughly 1-3 cm per year in central California; (*62*, *112*, *113*). In contrast, increases in the smallest (3 cm) size classes may reflect combined numerical (recruitment from smaller size classes) and behavioral responses. The observed increases in densities across all size classes of purple urchins suggest (i) responses to observed declines in sea star predators, and (ii) that significant levels of compensatory predation by otters on purple urchins have yet to be realized.

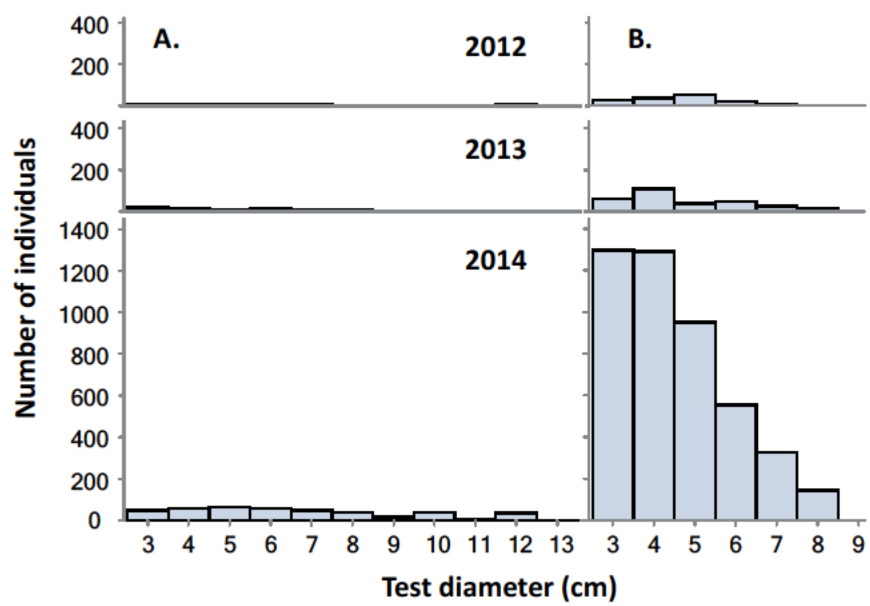

Figure 2. Size frequency distribution of (a) red sea urchins and (b) purple sea urchins observed on survey transects at sites identified in Figure 1 over the period 2012-2014.

Therefore, we propose to test several general hypotheses germane to the questions of whether

and how predator diversity (i.e. the presence of alternative predators) may buffer communities and ecosystems to perturbations. We draw from the ongoing biotic perturbation (epizootic) that has led to dramatic declines in populations of sea stars and explore the potential role of otters to buffer population responses of urchins that may otherwise lead to dramatic shifts in the structure and functions of kelp forest ecosystems in Central California.

Proposed Research to be Undertaken

Given this background, in this study we will address the following eight questions. Questions one through four will be addressed using experimental orthogonal manipulations of predators (otters, *Pisaster, Pycnopodia*) to observe the response of prey (purple urchins, *Promartynia*), and algae (*Macrocystis*). Question five will be addressed using kelp forest ecosystem surveys, and questions six through eight will be addressed using radio-tagging and observation of otters.

1) Predator effects on density and size of exposed prey. What are the separate and combined effects of otters and *Pisaster* or *Pycnopodia* on the density and size structure of *exposed* (i) purple urchins, (ii) *Promartynia* snails and (iii) young *Macrocystis* plants? *Exposed* urchins and snails are those not confined to crevices, reflecting active grazing and vulnerability to predation. Counts of exposed individuals in the orthogonal predator manipulations will indicate combined direct (mortality) and indirect trait-mediated (behavioral) predator effects.

2) Direct and trait-mediated effects of predators. What are the relative contributions of mortality (density effects) and behavioral responses (trait-mediated effects) to changes in the density of *exposed* urchins in response to the presence of predators (otters, *Pisaster* or *Pycnopodia*)? Evidence suggests that urchin responses to *Pisaster* are largely behavioral (not direct mortality) whereas responses to *Pycnopodia* and otters include both urchin mortality and behavior. These will be teased apart by distinguishing changes in density and size structure of exposed versus total urchins and snails in the orthogonal predator manipulations.

3) Redundant versus complementary predator effects. Do the different predators (otters, *Pisaster* and *Pycnopodia*) contribute differentially to reduced numbers of exposed prey (purple urchins and snails) of different size classes, reflecting complementarity among these predators across the size distribution of urchins and *Promartynia*? Because otters feed solely on larger size classes of urchins, control of urchin populations might be a function of sea star predation on smaller size classes and otter predation in larger size classes. This will be tested by comparing size frequency distributions of surviving urchins across the orthogonal manipulations of predator access, and combining these data with observational data on size-dependent consumption rates by tagged otters.

4) Cascading predator effects on kelp. Are the separate and combined effects of predators (otters, *Pisaster* and *Pycnopodia)* on the density and size structure of *exposed* purple urchins (based on combined numeric and trait-mediated responses) manifest in changes in mortality rate and density of young *Macrocystis* plants, reflecting a trophic cascade?

5) Larger scale manifestation of predator effects. Are the direction, strengths and mechanisms (mortality versus behavior) of predator-prey interactions, including the hypothesized three-level trophic interaction revealed in the controlled orthogonal experiment, manifest over time and among sites distributed across the study region? To test hypothesized spatial and temporal correlations in density and size structure) of prey (urchins, *snails*) and kelp (*Macrocystis* and other macroalgae) to variation in predator density (otter, *Pisaster*, *Pycnopodia*), we will conduct annual surveys across ten sites distributed across the study region. These results will indicate whether conclusions generated by the experiments (i) "scale-up" to explain variation in the structure and dynamics among kelp forests along the coast, and (ii) are robust to the environmental (reef structure, oceanography) and biotic (overall community structure) variation in these kelp forest ecosystems.

6) Sea otter behavioral responses. Does the rate of predation on and relative contribution of purple urchins and *Promartynia* in the diet of otters increase in response to declines in sea

star densities and increases in density of urchins and snails, as compared to “normal” variation in dietary prevalence over the past 15 years?

7) Co-variation of predators and prey. Is there spatial variation in the dietary response of sea (rate and success) and does this correspond to spatial variation in prey density (exposed urchins and *Promartynia*)?

8) Effect of individual specialization. Do spatial and dietary response vary predictably among individual otters based on historic and current patterns of dietary specialization? That is, does increased dietary prevalence of urchins and/or snails occur similarly for all otters, or is it only evident (or most pronounced) for urchin/snail diet specialists?

Approach:

We propose to answer the questions posed above with a combination of field experiments, ecosystem surveys, and telemetry-based studies. These methods will enable us to examine the consequences of reduced rates of sea star predation on urchins at two spatial scales. Experimental manipulations will identify causal effects of relative rates of predation at the scales of ($6m^2$) patches. Surveys conducted at ten sites over three years will identify spatial and temporal correlations among sea star, otter and giant kelp densities across natural variation in densities of these species as well as environmental conditions (reef structure, wave exposure). Observational data collected from radio-tagged otters will provide longitudinal information on variation in otter diets both at the population and individual level. Surveys and otter observations will evaluate the extent to which causal responses identified at the patch scale do or do not scale up to site level.

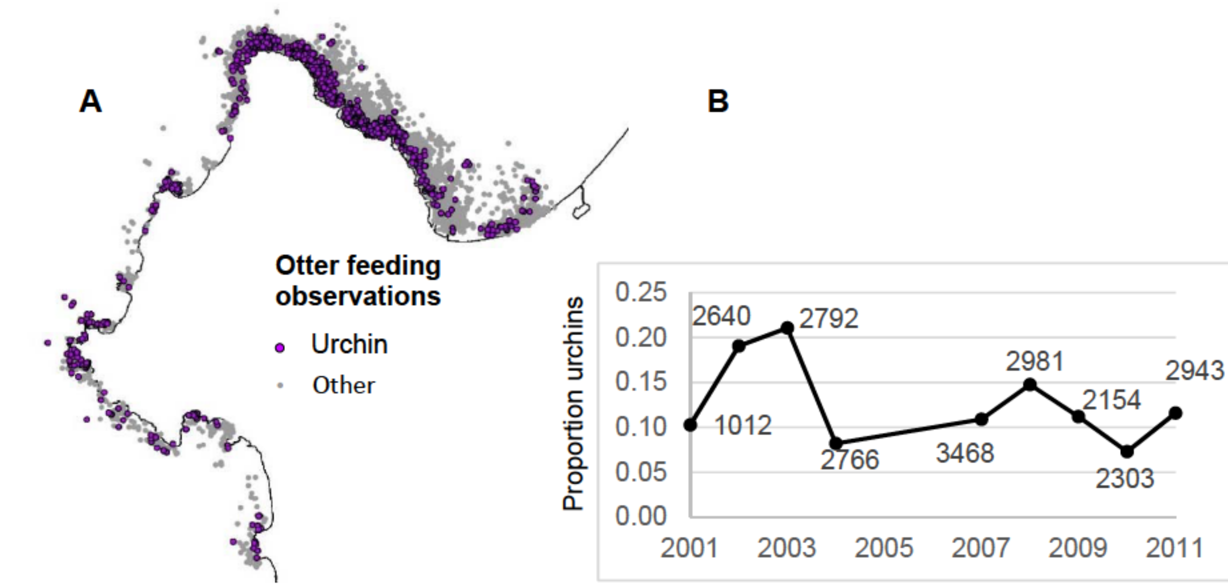

Figure 3 (A) Distribution of sea otter foraging activity: purple points indicate observations of otters feeding on urchins. **B**) Proportion of total feeding observations in which otters fed on urchins in the study region. Values indicate sample size (number of observations).

Orthogonal manipulation of urchin and snails predators

We propose to deploy 24 $6m^2$ cages designed to orthogonally manipulate the access of otters with access of either *Pisaster* or *Pycnopodia* to a size range of purple urchins and *Promartynia*. Orthogonal manipulations of otters and *Pisaster*, and otters and *Pycnopodia* will be conducted separately in year 1 and year 2 of the project, respectively. Depending on the rate of responses of predators and prey, Year 3 is a buffer for each of these experiments. Otherwise, a third

experiment orthogonally manipulating the two sea star species or prey (urchin) density refuge availability will be conducted.

Cage design: All 24 cages will be deployed at a depth of 10-12 m along a section of the northwest face of the Monterey peninsula where a history of otter foraging rates and behavior have been collected (Figures 1 and 3). Cages are 2m by 3m (6m^2) rectangles of 0.75 m height (Figure 4). The mesh is standard 11.5 gauge galvanized metal cyclone fencing (5cm x 5cm square mesh) and the structural supports are standard 4cm diameter galvanized steel cyclone fencing posts and three-way joints. All 24 cages have cyclone fencing walls, a cyclone fencing bottom and 10cm horizontal lips. The bottom, walls and lips of all 24 cages are lined with 1 cm sq galvanized mesh (hardware cloth) to prevent prey (urchins and snails) and sea stars from entering or leaving the cages. This allows us to control prey and sea star densities over the duration of the experiments. The 12 cages designed to exclude otters have two panels of cyclone fencing that enclose the top and are removable to allow divers to survey exposed urchins and snails. Top panels are secured to the horizontal supports at the top of the walls by heavy duty (1cm wide) plastic cable ties. The 12 cages designed to allow access of otters have no top. Horizontal lips at the top of the vertical walls are designed to prevent sea stars, urchins and snails from entering or leaving the cages, but tips of these horizontal lips may be painted with copper-base paint if necessary.

Reef habitat: To weight cages to the bottom and to standardize heterogeneity of the reef structure (i.e. visual detection of exposed prey and availability structural refuge for prey) rock boulders will be placed inside the cages. Size frequency (diameter) and shape of boulders will be similar across all 24 cages. The amount of rock habitat across all cages will be similarly adjusted to ensure sufficient structural refuge for the number of prey in each cage. This is required for the assessment of behavioral versus density responses to predator treatments (Question 2).

Spatial design: Six replicate cages of four orthogonal treatment levels (- otters -star; -otter +star; +otter -star; +otter, +star) will be spatially blocked with random placement of each treatment level per block. The design assumes that otters will access the two “otter accessible” treatment levels, based on the perceived influence of otters on urchin densities in the study region, the large number of otter-urchin feeding observations at the experimental site (Figure 3) and the relatively large area (6 m^2) of the cages. To test this assumption, a time lapse video recorder (GoPro) will be deployed at each block of four cages to monitor the frequency of otter access. Cages will be separated by a minimum of 5m to reduce the likelihood that predators will influence the behavior of prey in adjacent cages.

Prey manipulations: Natural densities and size structure of purple urchins and *Promartynia* snails will be established within cages at the onset of each experiment. Urchin dispersion is extremely patchy and our past surveys in the study region have detected upper densities of 15 per m^2 (= 90 per 6m^2 cage). Size frequency distributions of purple urchins are extremely variable, but using the distribution depicted in Figure 2 and making no size class less than 10 individuals, we will stock each cage with 22 3cm, 22 4cm, 16 5cm, 10 6cm, 10 7cm, and 10 8cm test diameter purple urchins. Watanabe (*74*) estimated mean density of adult *Promartynia* at 4 per m^2 and 40 per m^2 on rock bottom and kelp, respectively, and juvenile (< 16mm dia) *Promartynia* at 3 per m^2 and 227 per m^2 on rock and shell rubble habitat, respectively, at 12 m depth in southern Monterey Bay. Given this great variability, we will seed each cage with 60 *Promartynia*, allocated across three size classes: 30, 20 and 10 individuals in 1±0.5, 2±0.5 and 3±0.5 cm basal diameter. These size distributions of both urchins and snails reflect variation in natural size structure, to better mimic effects of encounter rates on a predator’s size selection,

but also increase numbers of larger size classes to characterize the observed changes in size distributions described above and avoid proportional inflation of loss of few individuals. Prey will

be placed in cages and cages will be covered with top panels for a 24 hrs acclimation period prior to adding or allowing access of predators. Using techniques described in Pearse and Pearse (*112*), all purple urchins added to cages will be treated with injections of tetracycline to mark the initial diameters of their tests. This will allow us to identify growth of individuals and immigrants to the cages by collecting and sampling all individuals at the end of the experimental trials.

Effect of grazer density and behavior on kelp survival: To determine the effect of changes in urchin and snail density and behavior on the survival and size structure of *Macrocystis*, we will add similar size rocks containing young *Macrocystis* plants to every cage. Reed and Foster (1984) recorded 9.6± 1.4 young *Macrocystis* recruits per m^2 in a forest on the Monterey peninsula. Recruitment is very patchily distributed, so we will distribute 10 (0.25m dia) rocks with six small (single stipe, 5-10cm height) *Macrocystis* plants each (total 60 plants) per cage. Rocks with young *Macrocystis* recruits are abundant at the proposed experimental site.

Sampling: One block of four cages will be sampled each day (all four blocks each week) for the duration of the study. Each sample, the number of exposed urchins and *Promartynia* will be counted and measured. Depending on the rate of change of treatment levels exposed to

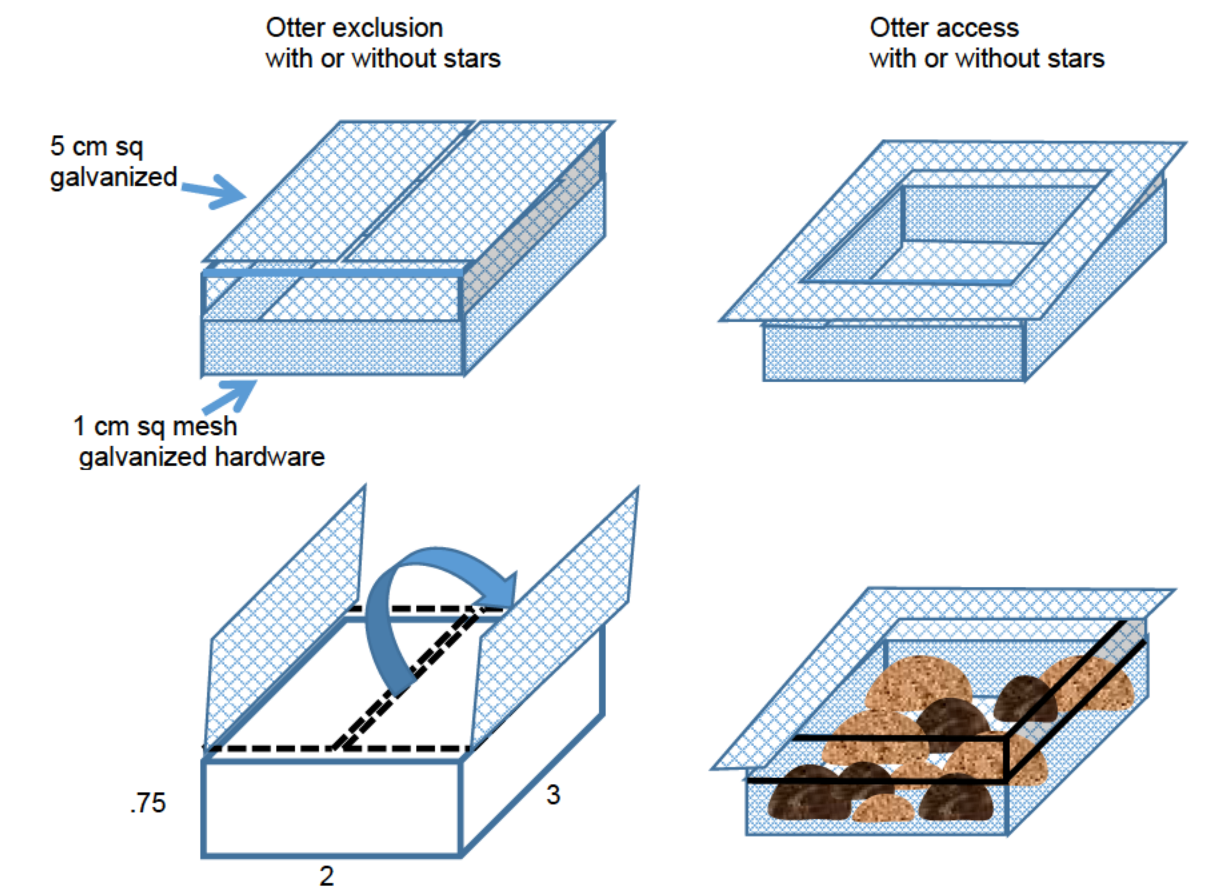

Figure 4. Predator exclusion/inclusion cages designed to (a) exclude sea otters with or without sea stars, or (b) allow access by sea otters with or without sea stars. Horizontal lips atop walls of otter accessible cages impede urchins, snails and stars from migrating in or out of cages. (c) Removable panels on otter exclusion cages allow divers to count and measure exposed and hidden sea urchins, snails and kelp. (d) Rocks are placed inside cages to standardize visual detection and refuge for prey, including rocks with young kelp.

predators, a total count of individuals (exposed and hidden) will be made at a frequency of two weeks (every other survey) to estimate the trajectory of the relative abundance of exposed and hidden individuals. More frequent estimates of total individuals will be made if declines in number of exposed individuals are rapid, less frequent if the decline is slow. The lower frequency of estimates of total number is to minimize the disturbance of searching for hidden individuals during the experiment. The number and height of each *Macrocystis* plant will be recorded on each survey.

Tests of hypotheses:

1) Predator effects on density and size of exposed prey. Density (number per cage) responses of exposed urchins, snails and kelp plants will be estimated as both the (i) slope of the decline in numbers per cage recorded weekly over the duration of the experiment, and (ii) comparison of final numbers of exposed individuals among treatment levels at the end of the experiment. The relative **separate** effects of predators are determined by comparing prey declines in each single-predator with no-predator treatment levels and comparing these differences between predators. Rates of decline and final densities will be compared among treatment levels with general linear model approaches (e. g., analyses of covariance – ANCOVA and ANOVA, respectively), assuming parametric assumptions are met. If not, we'll use a generalized approach. The **combined** effects are determined by comparing rates of decline and final densities observed in single-predator and two-predator treatments. The interaction term in these comparisons will be used to test for non-additive effects of predators. Signification interactions between pairs of predators may be positive (facilitated rates of predator foraging efficiency) or negative (interference between predators) (*114*, *115*). Separate and combined effects of predators on prey size structure will be tested similarly by comparing prey size distributions between no-predator, single-predator, and two-predator treatments. Differences in size distributions will be tested among the weekly samples and at the end of the experiment using a generalized linear model with a log-linear function. Comparison of changes in size structure over time between predator treatments indicates the relative predation rates on different size classes of prey. These differences will be evaluated by decomposing the model to test for the interactions among size (binned into the classes described above), time (weeks), and predator treatment levels. We predict differences in effects of predators based on their known selective foraging (e.g., otters on the largest size classes versus *Pycnopodia* on smaller size classes) and direct versus indirect effects (e.g., behavioral responses to *Pisaster* are likely to be greater for smaller urchins and more uniform across all size classes of snails).

2) Direct and trait-mediated effects of predators. Evidence suggests that urchin responses to *Pisaster* are largely behavioral (not direct mortality) whereas responses to *Pycnopodia* and otters include both mortality and behavioral responses. These will be teased apart by distinguishing changes in density of exposed versus total (exposed plus hidden) urchins and snails in the orthogonal predator manipulations. To avoid nonlinear responses due to limited refuge availability, we will determine that sufficient refuge is available for all prey at the beginning of the experiment, by using crushed urchins to elicit a refuge-seeking response and searching for any remaining exposed individuals. Crushed conspecifics elicit a very strong refuge seeking behavior in urchins (*58*). To test the hypothesis of differences in the relative contribution of direct density effects (mortality) and behavioral responses of exposed prey among the three predators, we will compare the relative rates of change in exposed vs. total prey among the four treatment levels. For example, we predict that any change in the relative frequency of exposed urchins over time would be attributed almost entirely to behavioral responses and little, if any, to mortality. Hence, the (negative) slope of exposed urchins over time would be significantly greater and different than the change in total number (i.e. time by response interaction). Because *Pycnopodia* would be an ever-present voracious predator of urchins and snails, we predict a significant decline in both exposed and total density, though the (negative) slope of decline in exposed individuals should still be greater than total number

because of a refuge effect. Because otter predation is episodic and possibly more thorough (turning of rocks) the rate of decline in total numbers and exposed numbers will be more similar to one another. These responses may well be non-linear. Generalized linear models (GLM) will be used to compare slopes between behavioral and density responses, between prey (urchins and snails) and between predators to evaluate how the relative strengths (contributions) of the behavioral and density effects vary by species of prey and predator.

3) Redundant versus complementary predator effects. Because otters feed solely on larger size classes of urchins, control of urchin populations might be a function of sea star predation on smaller size classes and otter predation in larger size classes. This will be tested by comparing size frequency distributions of surviving urchins across the orthogonal manipulations of predator access. As described in Question (1), differences in size distributions will be tested among the weekly samples and at the end of the experiment using a generalized linear model with a log-linear link function. Comparison of changes in size structure over time between predator treatments indicates the relative rates at which they influence the different size classes of prey. These differences will be evaluated by decomposing the model to test for the interactions among size (binned into the classes described above), time (weeks), and predator treatments to determine if the combined effects of both predators are additive or multiplicative on each size class.

4) Cascading predator effects on kelp. The cascading effect of predator control of grazer density and behavior is manifest in the survival and size of the foundational species, *Macrocystis*. Change in kelp density from those established at the onset of the experiment will be compared among the four predator treatment levels with general linear model approaches, assuming parametric assumptions are met, or generalized linear model, as described for Question (1). Differences in size distributions will be tested among the weekly samples and at the end of the experiment using a GLM with a log-linear link function. Comparison of changes in size structure over time between predator treatments indicates the relative rates at which they influence the different size classes of kelp. These differences will be evaluated by decomposing the model to test for the interactions among size (measured to the centimeter and binned into size classes depending on growth rate), time (weeks), and predator treatment levels. We predict that declines in kelp density will be greatest in cages excluding all predators, and least likely in the presence of both otters and *Pycnopodia*. Intermediate reductions may occur in the presence of *Pisaster*, however as in all cases of combined predator treatments, this depends on whether predator interactions are positive (facilitated rates of predator foraging efficiency) or negative (interference between predators).

5) Larger scale manifestation of predator effects. To test hypothesized spatial and temporal correlations in density and size structure (generated from the experiment) in prey (purple and red urchins, snails) and kelp (*Macrocystis* and other macroalgae) to variation in predator density (otter, *Pisaster*, *Pycnopodia*), we will conduct the annual surveys described below across 10 sites distributed across the study region.

Community surveys

We will conduct kelp forest community surveys at ten sites distributed throughout the Monterey Peninsula study region in order to (1) characterize the progression of predator (*Pisaster* and *Pycnopodia*), grazer (purple and red urchins, *Promartynia* and other herbivorous and detritivorous gastropods) and algae (*Macrocystis*, other kelps and foliose red algae) population dynamics, and (2) determine whether species interactions revealed in the caging experiment are manifest at the larger spatial scale of forests and the greater natural variability of environmental (biological and physical) conditions among forests. Survey sites include those for which we have a long-term (9-16 year) baseline characterization of community structure prior to at and at the onset of the sea star wasting epidemic (Figure 1). These sites also include baseline characterizations of otter density and foraging behavior (see below). At a subset of these sites, continued otter surveys will allow us to (3) determine how otter distribution and

foraging behavior respond to changes in prey (urchin and snails) and alternative predator (*Pisaster* and *Pycnopodia*) densities estimated by the benthic community surveys.

Each survey "site" is comprised of two halves side by side along the shoreline, in which two 30m long x 2m wide swaths are located along each of three isobaths (5m, 12.5m and 20m depth) from the inshore to the offshore width of the forest. Surveys will be conducted annually (July-early September) at each site in each year of the study period. Details of species lists and sampling protocols are available at http://www.piscoweb.org/research/science-by-discipline/ecosystem-monitoring/kelp-forest-monitoring/subtidal-sampling-protoco.Generally, on each of the twelve 60m^2 transects, densities of conspicuous (> 2.5cm dia) size classes of common invertebrates are recorded. Size frequencies of urchins and sea stars are recorded in the same categories described in the experiment. Densities of juvenile (> 1m height) and adults of the two canopy-forming (*Macrocystis* and *Nereocystis*) kelps, subcanopy-forming stipitate (> 30 cm height) kelps, and prostrate (> 10cm blade width) kelps and erect (> 6cm height) fucoids (e.g., *Cystoseira*) are recorded. Stratified subsampling is used to estimate densities of particularly abundant species such as urchins and snails. The distance along the transect in which the first 30 individuals are counted is recorded and this is repeated for each of three 10m subsections of the transect.

Uniform point contact is sampled (30 points at 1m intervals) to estimate percent cover of five morphological categories of foliose red algae, erect and encrusting coralline algae, and species of brown algae (e.g., Dictyotales). Percent cover of colonial or aggregating invertebrates are recorded at higher phyletic levels of taxonomic resolution (e.g., bryozoan, sponge, tunicate). Percent cover is also used to characterize the relative abundance of structural features of the rocky reef, including substratum type (sand, cobble, boulder, bedrock) and relief (0-10cm, 10cm-1m, 1m-2m, > 2m).

We will continue to follow urchin density and size-structure to track the progression of size classes, including recruitment and survivorship of the successful recruitment class seen in 2014. We will also record whether each individual urchin is exposed versus sheltered to estimate change in the proportion of exposed individuals. This will allow us to quantify the magnitude of the behavioral and possible demographic response to the decline of sea stars and how these correlate with spatial and temporal variation in combinations of relative densities of predators (otters, *Pisaster* and *Pycnopodia*).

We will test for temporal and spatial relationships between univariate (e.g., individual predator densities) and multivariate (e.g., relative abundances of predators) independent variables and univariate response variables (e.g., proportion of urchins exposed, urchin density, kelp density) and multivariate response variables (e.g., combinations of urchin and kelp densities). We will use ordinary least squares regression for these analyses, testing for spatial autocorrelation in residuals and, if significant, using geographically weighted regression analysis (*116*) to correct for bias.

6) Sea otter behavioral responses. To address the question of how sea otters have or have not responded to the sea star decline at larger scales, we will initiate a telemetry-based study of tagged otters, sampled randomly from within the study area, from which we will collect observational data on otter diets for comparison with equivalent data collected over the past 15 years in the same area (Figure 3; (*99*, *103*)).

Sea otter tagging, monitoring and data collection

We will capture and tag a sample of approximately 25 otters from the study area (north and west side of Monterey peninsula) following methods we have utilized for many previous studies in this area (*99*, *117*). All methods described below are covered under current Federal permits to T. Tinker and authorized by the UC Santa Cruz Institutional Animal Care and Use Committee (IACUC). Captures are conducted by a highly experienced and uniquely trained sea otter

capture team using closed-circuit SCUBA methods, underwater propulsion devices and specialized “wilson traps” (*118*). Captured animals are transported to the Monterey Bay Aquarium (MBA) for processing by an experienced veterinary team: animals are anaesthetized, tagged, and receive comprehensive health exams and bio-sampling. Anaesthetization follows well established protocols (*119*), and once unconscious each animal is equipped with color-coded flipper tags for visual identification and a surgically implanted VHF transmitter for radio telemetry tracking. Samples collected include blood (used for screening a standardized series of blood parameters, to evaluate health and contaminant/disease exposure), saliva and fur (for stress hormone analyses), and vibrissae which are used to evaluate long-term individual diets via stable isotope analysis (*120*, *121*). Participants in the capture/tagging phase include scuba divers and boat operators from UC Santa Cruz, USGS and California Department of Fish and Wildlife (CDFW), and veterinarians and staff from MBA.

After release, study animals are monitored regularly (using standardized VHF telemetry protocols: (*117*)) over the subsequent 3-year period corresponding to the transmitter battery life. Field personnel conduct shore-based daily surveys of the study site using standard telemetric protocols to locate all study animals (triangulation on radio signal using VHF telemetry receivers and visual identification using 50-80X Questar spotting scopes) and record precise GPS position, survival, reproductive status and instantaneous behavior. Attempts will be made to re-sight all study animals at least 5 times per week. Individual study animals are then selected haphazardly (subject to appropriate behavior and visual conditions) for collection of observational data on diet and feeding behavior, following well-established protocols (*99*, *102*, *122*, *123*). Briefly, the otter is observed using 50-80X spotting scopes (Questar Inc., Isanti, MN) over a contiguous sequence of 20 - 60 dives, referred to as a foraging bout. Information recorded includes date and time, precise location of each dive (determined by visual triangulation using GPS, compass and laser range-finder), duration of the subsurface dive interval (“ DT”) and the post-dive surface interval (“ST”) for each feeding dive (in seconds), outcome of each dive (i.e. whether or not prey was captured), species of prey captured, number and size of prey items, per-item handling time (number of seconds required to handle and consume each item), whether or not tools were used to handle the prey, and ambient conditions (including sea-state, wind, etc.). Prey size is recorded as the estimated diameter of the shell or maximum body dimension (excluding appendages), categorized into 2.5 cm size-classes. For observations where prey cannot be reliably identified to species, the items in question are assigned to the lowest possible taxonomic unit. Any items that cannot be reliably categorized to any taxonomic level are listed as “unidentified”. Additional information recorded by observers includes numbers of prey items that were stolen by or from the focal animal and, in the case of females with dependent pups, the number of items that were shared with the pups. Data are then analyzed to estimate prey-specific consumption rates, using a resampling procedure that uses Monte Carlo simulations to account for missing data parameters and adjust for sampling bias (see Tinker et al 2012, 2015).

We will attempt to collect 500-1000 dives per study animal over a 3 year period, augmented by an additional 5000 dives from randomly selected untagged otters in the same area, for a total sample size of ~15,000 recorded feeding dives. We will estimate the per-capita rate of predation on urchins and marine snails, and compare these with estimates available for 1999-2014 (for which we have an existing data set of over 60,000 recorded dives). We will used mixed-effects linear models (with individual otter treated as a random effect) to test for temporal trends in prey consumption rates.

7) Co-variation of predators and prey. To address this question, we will combine spatially-explicit data on prey consumption by otters (see above; Figure 3) with site-specific data on urchin and snail abundance from subtidal surveys. We will test for a relationship between prey abundance and otter consumption rates using ordinary least squares regression analysis. We

will test for spatial autocorrelation in residuals and, if significant, use geographically weighted regression analysis (*116*) to correct for bias.

8) Effect of Individual Specialization. Based on previously published analyses of otter diets around Monterey peninsula, we know that individual otters tend to specialize on a small suite of prey, such that the high diet diversity occurring at the population level is actually an emergent phenomenon reflecting the diversification of specialized diets among individuals (*99*, *102*, *103*, *120*, *121*). We might therefore expect that those otters specializing on a diet high in urchins or snails would show the earliest and most significant response to the increase in urchins and snails resulting from the local extinction of sea stars. This hypothesis implies an enhanced degree of individual specialization. An alternative hypothesis is that all otters will respond similarly to the "windfall" created by the sudden glut of urchins, a pattern that would imply a relaxation of individual specialization as all individual diets became more similar. To test these predictions, we will compare the degree of individual specialization in our current sample of tagged otters to that observed over the period 1999-2014. We will use diet similarity indices (*124*) to compare diets among individuals and to quantify the level of specialization for each study group.

Intellectual Merit

This project will advance our understanding of the combined roles of species diversity and predators in contributing to the stability and resilience of community structure. Though both of these elements of community structure have been the focus of numerous studies, fewer have explored how predator diversity does or does not enhance the resilience of marine ecosystems in field experiments. Specifically, elucidation of both the relative importance of direct (mortality) and indirect (prey behavior) trait-mediated effects of predators on prey density and foraging behavior, while simultaneously identifying the mechanisms (i.e. redundancy, complementarity) by which predator diversity determines the strength of this effect is critical to advancing our understanding of the roles of diversity and predation for ecosystem resilience. Dissecting these complex species interactions with unprecedented controlled field experiments to assess their causal relationships at scales relevant to real patch dynamics, combined with field surveys to evaluate their manifestation at scales of the whole ecosystem (kelp forests) collectively constitute the transformative potential of this research. Kelp forest ecosystems throughout temperate oceans in both southern (South America, New Zealand, Tasmania, southern Australia) and northern (New England) hemispheres, especially along the West Coast of North America (Mexico to Alaska), have had profound influence on our understanding of how abiotic (e.g., storm disturbance) and biotic (especially the role of predators) processes determine ecosystem stability and resiliency. By exploring these species interactions in kelp forest ecosystems, we capitalize on an extraordinary foundation of ecological understanding, hence the rationale for our focus on this system. In addition, the results of this study will inform our understanding of the ecological consequences and reasons for the extent and duration of ecosystem-wide impacts of the current sea star wasting event.

Broader Impacts

The broader impacts of this study include: graduate and undergraduate training, public outreach, and informing conservation managers and policy makers. Graduate training will be achieved through co-mentoring of one graduate student funded by this award by the two PIs. The graduate student will be involved in field studies, develop a species interaction model to explore the hypothesized interactions, and participate directly in outreach efforts. Marine Biology is one of the largest majors at UC Santa Cruz, with 260 current undergraduates. The program serves a substantial proportion of underrepresented students, including many Latino students who are the first in their family to pursue a college education. Undergraduate students pulled from this rich pool, will assist graduate students, faculty and researchers in all aspects of the study.

Our outreach efforts will have three main audiences: K-12 students, the general public, and marine resource managers. These efforts will be designed to provide information about the ecosystem consequences of sea star declines and the role of predator diversity in contributing to the resiliency of kelp forest ecosystems. Our outreach efforts will target four unique opportunities: the Monterey Bay Aquarium, the Seymour Discover Center on the UCSC Coastal Science Campus, UCSC's Broader Impacts Office, and a popular interactive website on sea star wasting information.

Based on the close involvement in this project of sea otter observers trained by the Monterey Bay Aquarium (MBAq), the Aquarium's Conservation program will facilitate disseminating information about the study and its results through their extensive outreach program, including a huge K-12 educational program (see letter of commitment and support submitted by MBAq.

UCSC is strongly committed to Broader Impacts (BI) and has developed a BI Office to facilitate researchers achieving the broader impacts of their research (http://officeofresearch.ucsc.edu /broader-impacts/). Among the many outreach avenues identified by the BI Office, the Seymour Marine Discovery Center (http://seymourcenter.ucsc.edu/) located on UCSC's Coastal Science Campus provides a conduit to K-12 programs and general public who visit the Center. We will co-develop a video presentation with the Center's display team through this grant and a collaboration with the Science Communication program at UC Santa Cruz (http://scicom.ucsc.edu). This video will build upon existing work at the Seymour Center to develop a video display, funded by earlier NSF support (see letter of commitment and support from the Center's Director).

Associated investigator Raimondi maintains a website and interactive map for tracking the incidence of sea star wasting (http://www.eeb.ucsc.edu/pacificrockyintertidal/dataproducts/ sea-star-wasting/), which we will continue to inform throughout the project. This website provides information to the interested public as well as a nexus for information exchange between scientific colleagues.

Management and policy institutions whose decisions and actions will benefit from the findings of this project include California's Department of Fish and Wildlife (CDFW) and Ocean Science Trust, which houses the state's Monitoring Enterprise. Both agencies are tasked with monitoring and managing marine protected areas (MPAs). Both institutions will benefit from knowledge of the ecological mechanisms that may underpin the geographic variation, including inside and outside of MPAs, in the dynamics of the wasting event, including the ecosystem-wide consequences of reduced sea star densities, and the mechanisms of resiliency of kelp forests. The PIs are well situated to ensure that this study informs MPA managers in California. PI Carr and associated investigator Raimondi both work closely with California's Monitoring Enterprise (http://monitoringenterprise.org/where/california.php) and the CDFW on the monitoring, assessment and applications of MPAs (see Synergistic Activities sections of their CVs). Federal agencies that will benefit from knowledge generated by the study include The Monterey Bay National Marine Sanctuary (MBNMS), tasked with evaluating and protecting the status of the Sanctuary's ecosystems, and the USGS Western Ecological Research Center, responsible for understanding both the ecological significance of the otter and processes that influence its recovery (e.g., kelp forest resiliency). Involvement of associated investigator Lonhart (MBNMS) and Co-PI Tinker (USGS) will ensure that MBNMS and USGS are well informed of the results of this study.

Results from prior NSF support:
(a) NSF award number: OCE-1041454, **amount:** $465,078, **period of support:** 07/15/2010 - 06/30/2014, Mark H Carr, Principal Investigator; James A Estes, Co-Principal Investigator. Dr. Jennifer Caselle was Principal Investigator on the **collaborative award number:** OCE-10411489**.**
(b) title: CAMEO: Comparative Approaches to Predicting the Consequences of an Impending Re-Invasion: Top Predator Effects on Californian Near-Shore Fisheries

Relevant Sea Otter Publications resulting from prior versions of MA672624

Fujii, J.A., Ralls K, **Tinker M.T**. (2017) Food abundance, prey morphology, and diet specialization influence individual sea otter tool-use. Behavioral Ecology, 28(5), 1206-1216. doi:https://doi.10.1093/beheco/arx011

Ralls K, Rotzel McInerney N, Gagne RB, Ernest HB, **Tinker MT**, **Fujii J**, Maldonado J. 2017. Mitogenomes and relatedness do not predict frequency of tool use by sea otters. Biology Letters13 (3), 20160880

Tinker, M. T., **J. Tomoleoni**, **N. LaRoche**, L. Bowen, A. K. Miles, M. Murray, **M. Staedler**, and **Z. Randell**. 2017. Southern sea otter range expansion and habitat use in the Santa Barbara Channel, California. USGS Open File Report 2017-1001, Reston, VA.

Breed, G. A., **E. A. Golson** and **M. T. Tinker**. 2017. Predicting animal home range structure and transitions using a multistate Ornstein-Uhlenbeck biased random walk. Ecology,98(1), 32-47. Doi:10.1002/ecy.1615

Thometz, N.M., Staedler, M.M., Tomoleoni, J.A., Bodkin, J.L., **Bentall, G.B., Tinker, M.T.** 2016. Trade-offs between energy maximization and parental care in a central place forager, the sea otter. Behavioral Ecology, 27(5): 1552-1566

Tinker, M.T., Staedler, M.M., Tarjan, L.M., Bental, G.B., Tomoleoni, J.A., and LaRoche, N.L., 2016, Geospatial data collected from tagged sea otters in central California, 1998-2012: U.S Geological Survey data release, http://www.dx.doi.org/10.5066/F76H4FH8.

Tarjan, L.M., and M. T. Tinker. 2016. Permissible Home Range Estimation (PHRE) in Restricted Habitats: A New Algorithm and an Evaluation for Sea Otters. PLoS One

Chinn, S. M., M. A. Miller, **M. T. Tinker, M. M. Staedler**, F. I. Batac, **E. M. Dodd**, L. A. Henkel. 2016. The High Cost of Motherhood: End-Lactation Syndrome in Southern Sea Otters. Journal of Wildlife Diseases, 52(2):307-318. doi: 10.7589/2015-06-158

Tinker, M.T., B. B. Hatfield, M. D. Harris, and J. A. Ames. 2015. Dramatic Increase in Sea Otter Mortality from White Sharks in California. Marine Mammal Science, 32(1): 309–326,

Novak, M. and **M.T. Tinker**. 2015. Time-scales alter the inferred strength and temporal consistency of intraspecific diet specialization. Oecologia 178:61–74

Newsome, S.D., **M.T. Tinker**, V.A. Gill, Z.N. Hoyt, A. Doroff, L. Nichol, and J.L. Bodkin. 2015. The interaction of intraspecific competition and habitat on individual diet specialization: a near range-wide examination of sea otters. Oecologia, 178: 45-59

Smith, E.A.E., S.D. Newsome, **J.A. Estes and M.T. Tinker**. 2015. The cost of reproduction: differential resource specialization in female and male California sea otters. Oecologia, 178:17-29

Fujii, J. A., K. Ralls, and **M. T. Tinker**. 2015. Ecological drivers of variation in tool-use frequency across sea otter populations. Behavioral Ecology, 26(2) 519-526

Bowen, L., A. K. Miles, C. A. Kolden, J. A. Saarinen, J. L. Bodkin, M. J. Murray, and **M. T. Tinker**. 2014. Effects of wildfire on sea otter (Enhydra lutris) gene transcript profiles. Marine Mammal Science, 31(1):191–210

Lafferty, K.D. and **Tinker, M.T**. 2014. Sea otters are recolonizing southern California in fits and starts. Ecosphere (Ecological Society of America) 5:art50

Thometz, N. M, Tinker, M. T., Staedler, M.M., Mayer, K.A., and Williams, T.M. 2014. Energetic Demands of Immature Sea Otters from Birth to Weaning: Implications for maternal costs, reproductive behavior, and population level trends. Journal of Experimental Biology 217, 2053-2061

Kenner, M. C., **J. A. Estes**, **M. T. Tinker**, J. L. Bodkin, R. K. Cowen, C. Harrold, B. B. Hatfield, M. Novak, A. Rassweiler, and D. C. Reed. (*in press*) A multi-decade time series of kelp forest community structure at San Nicolas Island, California. Ecology.

Hughes, B. B., R. Eby, E. Van Dyke, **M. T. Tinker**, C. I. Marks, K. S. Johnson, and K. Wasson. 2013. Recovery of a top predator mediates negative eutrophic effects on seagrass. Proceedings of the National Academy of Sciences. doi:10.1073/pnas.1302805110

Oates, S.C., Miller, M.A., Hardin, D., Conrad, P.A., Melli, A., Jessup, D.A., Dominik, C., Roug, A., **Tinker, M.T.**, Miller, W.A. 2012. Prevalence, Environmental Loading, and Molecular Characterization of Cryptosporidium and Giardia Isolates from Domestic and Wild Animals along the Central California Coast. Applied and Environmental Microbiology. 78(24): 8762–8772

Tinker M.T., Guimarães P.R., Novak M., Marquitti F.M.D., L. B.J., Staedler M., Bentall G. & **J.A. Estes**. 2012. Structure and mechanism of diet specialization: testing models of individual variation in resource use with sea otters. Ecology Letters 15(5) 475-483.

Bowen L., Miles A.K., Murray M., Haulena M., Tuttle J., Van Bonn W., Adams L., Bodkin J.L., Ballachey B., Estes J., **Tinker M.T.**, Keister R. & Stott J.L. 2012. Gene transcription in sea otters (Enhydra lutris); development of a diagnostic tool for sea otter and ecosystem health. Molecular Ecology Resources 12:67-74.

Kim SL, **Tinker MT**, **Estes JA**, Koch PL. 2012. Ontogenetic and Among-Individual Variation in Foraging Strategies of Northeast Pacific White Sharks Based on Stable Isotope Analysis. PLoS ONE 7(9): e45068. doi:10.1371/journal.pone.0045068

Newsome, Seth D., Justin D. Yeakel, Patrick V. Wheatley, **M. Tim Tinker**. 2012. Tools for quantifying isotopic niche space and dietary variation at the individual and population level. Journal of Mammalogy 93(2), 329-341.

Estes, J.A. J. Terborgh, J. S. Brashares, M.E. Power, J. Berger, W. J. Bond, S. R. Carpenter, T. Essington, R. D. Holt, J. B.C. Jackson, R. J. Marquis, L. Oksanen, T. Oksanen, R. T. Paine, E. K. Pikitch, W. J. Ripple, S. A. Sandin, M. Scheffer, T. W. Schoener, J. B. Shurin, A. R.E. Sinclair, M. E. Soulé, R. Virtanen, and D. A. Wardle. 2011. Trophic downgrading of planet earth. Science 333:301-306

Watson, J. and **J.A. Estes.** 2011. Stability, resilience, and phase shifts in kelp forest communities along the west coast of Vancouver Island, Canada. Ecological Monographs 81:215-239.

Hatfield, B.B., J.A. Ames, **J.A. Estes**, **M.T. Tinker**, E.B. Johnson, **M.M. Staedler**, and M.D. Harris. 2011. Sea otter mortality in fish and shellfish traps: estimating potential impacts and exploring possible solutions. Endangered Species Research 13:219-229.

Novak, M., J.T. Wootton, D.F. Doak, M. Emmerson, **J.A. Estes**, and **M.T. Tinker**. 2011. Predicting community responses to perturbations in the face of imperfect knowledge and network complexity. Ecology 92:836-846.

Harris, Heather S., Stori C. Oates, **Michelle M. Staedler**, **M. Tim Tinker**, David A. Jessup, James T. Harvey, and Melissa A. Miller. 2010. Behavior Associated with Forced Copulation of Juvenile Pacific Harbor Seals (*Phoca vitulina richardsi*) by Southern Sea Otters (*Enhydra lutris nereis*). Aquatic Mammals 36(4): 219-229.

Miller, Melissa A., Raphael M. Kudela, Abdu Mekebri, Dave Crane, Stori C. Oates, **M. Timothy Tinker**, **Michelle Staedler**, Woutrina A. Miller, Sharon Toy-Choutka, Clare Dominik, Dane Hardin, Gregg Langlois, Michael Murray, Kim Ward, David A. Jessup. 2010. Evidence for a Novel Marine Harmful Algal Bloom: Cyanotoxin (Microcystin) Transfer from Land to Sea Otters. PLoS ONE 5(9):e12576.

Conrad, P. A., E. VanWormer, K. Shapiro, M. Miller, C. Kreuder-Johnson, **T. Tinker**, M. Grigg, J. Largier, T. Carpenter, and J. K. Mazet. 2009. Tracking toxoplasma gondii from land to sea. American Journal of Tropical Medicine and Hygiene 81:198-198.

Jessup, D.A., C. Kreuder-Johnson, **J.A. Estes**, D. Carlson-Bremer, W.M. Jarmin, S. Reese, E. Dodd, **M.T. Tinker**, and M.H. Ziccardi. 2010. Persistent organic pollutants in the blood of free ranging sea otters (*Enhydra lutris* sp.) in Alaska and California. Journal of Wildlife Diseases 46(4):1-20.

Newsome, S.D., **G.B. Bentall**, **M.T. Tinker**, O.T. Oftedal, K. Ralls, M.L. Fogel, and **J.A. Estes**. 2010. Variation in δ13C and δ15N diet-vibrissae trophic discrimination factors in a wild population of California sea otters (Enhydra lutris nereis). Ecological Applications 20:744-752.

Miles, A.K., M.A. Ricca, R.G. Anthony, and **J.A. Estes**. 2009. Organochlorine contaminants in fishes from coastal waters west of Amukta Pass, Aleutian Islands, Alaska, USA. Environmental Toxicology and Chemistry 28:1643-1654.

Tinker, M. T., M. Mangel, and **J. A. Estes**. 2009 Learning to be different: acquired skills, social learning, frequency dependence and environmental variation can cause behaviorally-mediated foraging specializations. Evolutionary Ecology Research, 11: 841-869.

Newsome, S.D., **M.T. Tinker**, D.H. Monson, O.T. Oftedal, K. Ralls, **M. Staedler**, M.L. Fogel, and **J.A. Estes.** 2009. Using stable isotopes to investigate individual diet specialization in California sea otters (*Enhydra lutris nereis*). Ecology 90: 961-974.

Johnson, C.K., **Tinker, M.T.**, **Estes, J.A.**, Conrad, P.A., **Staedler, M.**, Miller, M.A., Jessup, D.A. and Mazet, J.A.K. 2009. Prey choice and habitat use drive sea otter pathogen exposure in a resource-limited coastal system. Proceedings of the National Academy of Sciences 106(7):2242-2247.

Anthony, R.G., **J.A. Estes,** M. A. Ricca, A. K. Miles, and E. D. Forsman. 2008. Bald eagles and sea otters in the Aleutian archipelago: indirect effects of trophic cascades. Ecology 89:2725-2735

Tinker, M. T., D. F. Doak, and **J. A. Estes.** 2008. Using demography and movement behavior to predict range expansion of the southern sea otter. Ecological Applications 18(7) 1781-1794.

Tinker, M.T., **Bentall, G.B.**, and **J.A. Estes**. 2008. Food limitation leads to behavioral diversification and dietary specialization in sea otters. Proceedings of the National Academy of Sciences 105(2):560-565.

Cara Lisa Field, DVM, Ph.D

Curriculum vitae

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EDUCATION

Doctor of Veterinary Medicine, University of California- Davis Davis CA. June 2005

Ph.D, Comparative Pathology, University of California- Davis, Davis CA. June 2005

Dissertation Title: A biophysical characterization of Northern Elephant Seal (*Mirounga angustirostris*) blood platelets and their response to temperature and pressure changes.

B.S. Physiology, Spanish minor, University of California- Davis, Davis CA. June 1993

PROFESSIONAL EXPERIENCE

Staff Veterinarian, The Marine Mammal Center, Sausalito, CA. Oct 2014-**present**

- Veterinary care for stranded marine mammals including clinical medicine and surgery, emergency treatment, necropsy, records and supervise animal husbandry
- Supervise and train full-time veterinary intern, residents, and students in marine mammal medicine
- Outreach with general public, media regarding animal health and institution mission,
- Develop clinical techniques, studies and research projects, present clinical cases and research findings in professional scientific and public forums

Senior Associate Veterinarian, Georgia Aquarium, Atlanta, GA. Jan 2014-Sep 2014

- Clinical and preventative health care of marine mammal, fish, avian, reptile, amphibian and invertebrate collection, including medical and surgical procedures, advanced diagnostics, necropsy, more
- Directly oversee, instruct and mentor full-time veterinary residents and student extern program
- Outreach with general public, media regarding animal health, role of aquaria/zoological institutions
- Present clinical cases and research findings in professional scientific and public forums, including the following projects: beluga exhale sampling, efficacy of carprofen in cownose rays, penguin and elasmobranch protein/lipoprotein electrophoresis, propofol use in elasmobranchs, blood transfusions in elasmobranchs

Associate Veterinarian, Georgia Aquarium, Atlanta, GA. Jan 2012- Jan 2014

- Clinical and preventative health care of above collection above
- Instruction/mentorship of veterinary residents, veterinary intern/fellow and vet student extern program
- Outreach with students, general public, media regarding marine system and animal health
- Clinical research and case presentations at professional scientific and public forums

Associate Veterinarian, Audubon Nature Institute**.** New Orleans, LA. Aug 2009- Jan 2012

- Clinical and preventative health care for extensive aquarium, zoo and endangered Species Survival Center collections (medical/surgical procedures, reproductive laparoscopic techniques, necropsy, remote anesthetic delivery system use
- Continuous instruction/mentorship of veterinary residents, interns, vet student externs
- Veterinarian for Louisiana Marine Mammal and Sea Turtle Rescue Program including rescue, rehabilitation/veterinary care, release and tracking of stranded animals, necropsy, staff/intern training
- Onsite coordinator/manager/clinician for oiled sea turtles and dolphins during the BP Gulf Oil Spill 2010 and concurrent dolphin UME. Evidence collection/handling, chain of custody, HazMat training, supervision of rehabilitation efforts of large group of vets, students, interns, volunteers

Post-Doctoral Fellow, Mystic Aquarium/ Univ. of Connecticut**,** Mystic, CT. June 2008 - Aug 2009

- Conduct original cell biological research of marine mammal brucellosis and run diagnostic testing program
- Present research findings in public and professional forums including publications

- Mentor/instruct veterinary intern and students, and research program interns (undergrad, graduate)
- Veterinary care of large marine mammal and fish collection, and stranded marine mammals

Veterinary Intern in Aquatic Medicine, Mystic Aquarium, Mystic, CT. June 2007-June 2008

- Primary veterinary care for diverse marine mammal, fish, avian, reptile and invertebrate collection and stranded animals, including medical and surgical treatments, advanced diagnostics, remote anesthetic/medication delivery
- Design, conduct, present individual research project in cownose stingrays; marine Brucella research
- Instruct veterinary students, undergraduates and volunteers in medicine, research, stranding response
- Education/outreach with the general public

Post-Doctoral Researcher, Mystic Aquarium, Mystic, CT. Jul 2006- Jun 2007

- Serologic, molecular, microbiological and cell biological research for NOAA-OHHI marine Brucella grant
- Present scientific findings in public forums (conferences and publications)
- Assist veterinary staff with collection and stranded animal care and necropsies
- Collaborative human diving research project with US Navy

Contract Veterinarian, Luv My Pet Clinics CT/RI. Part time; August 2006- August 2009

- Small animal low cost vaccination clinic, microchip implantation, diagnostic testing

Staff Veterinarian, Humane Society of Sonoma County, Santa Rosa, CA. Jul 2005- Jun 2006.

- Shelter and private small/exotic animal medicine and management
- Public/community outreach including lectures in animal first aid and emergency response

Research Assistant in Cell Biology, Dept.of Anatomy, Physiology and Cell Biology. 1998- 2003 University of California- Davis, Davis, CA. Concurrent with Ph.D program

Post-graduate Researcher, Dept of Anatomy, Physiol, Cell Biology. UC Davis, Davis CA. 1995-1998

- Research in cellular biological techniques including characterization of platelet interactions for sickle cell anemia, characterization of mammalian species megakaryocytes, mammalian platelet membrane phase transition evaluation.

TEACHING EXPERIENCE

Instructor AQUAVET® 1; University of Pennsylvania/Cornell University, June 2009 - 2014. Marine mammal taxonomy, life history anatomy, physiology, medicine, research, necropsy

Instructor AQUAVET® 3; Georgia Aquarium, June-July, 2013 and 2014. Instruction of select group of veterinary students in aquatic animal anatomy, physiology and medicine, including marine mammals, teleosts, elasmobranchs, invertebrates, reptiles, amphibians, zoonosis and more

Instructor Oiled Wildlife Care Workshop. University of Georgia Athens, Feb 24, 2014

Instructor Advanced Fish Medicine; University of Florida/ Georgia Aquarium, March 2013.

Coordinator/Instructor Sea Turtle and Marine Mammal Workshop. New Orleans, LA; January 28, 2012. Effects of Oil on Wildlife Conference: created, organized and conducted workshop in sea turtle and marine mammal anatomy, physiology, habitat, distribution, and oil spill response.

Instructor/Coordinator Marine Mammal Biology Seminar course. U. Connecticut/ U. Rhode Island/ Mystic Aquarium; January 2009- May 2009; instructor 2008

Teaching Assistant: Biology, Dept.of Biological Sciences. University of California- Davis, Davis, CA. Sept-Dec, 1999

RELATED EXPERIENCE

Belize Manatee Tagging and Health Assessment: Belize, May 27-June 8, 2013, with USGS/ Sea to Shore/ Oceanic Society. Veterinary support during wild manatee tagging, health assessment and population investigation

UME Co-Investigator: Feb 2010 to present: Ongoing Gulf of Mexico dolphin Unusual Mortality Event

Dolphin Health Assessment: Aug 3-17, 2011. NOAA/NMFS evaluation of local wild bottlenose dolphin health post Deepwater Horizon oil spill in Barataria Bay, Grand Isle, LA.

Chemical Immobilization of Animals, Feb 2010, Baton Rouge, LA. Safe Capture International Inc. 16 hour workshop in safe immobilization of mixed animal species

Florida Manatee Health Assessment: December, 2009. Crystal River, Florida. Wild manatee captures for health evaluation and research, with USGS and University of Florida

Beluga Whale Field Research: Jun-Jul 2009, Point Lay, Alaska. Wild beluga sample collection

The Marine Mammal Center Veterinary Externships: Apr-May 2005. Sausalito, CA. Stranded marine mammal care including rescue and rehabilitation, medicine, surgery, anesthesia, necropsy
Oiled Wildlife Care Network Veterinary Externship, Feb 2005. University of California, Davis. Rescue, care and release of oiled wildlife, particularly avian species
Mote Marine Laboratory Veterinary Externship, Aug 2004. Sarasota, FL. Rehabilitation of stranded sea turtles and cetaceans, collection animal care, local wildlife rehabilitation at neighboring avian/wildlife rehab center (Pelican Mans)
Bodega Bay Marine Biology research program, Bodega Bay Marine Laboratory, UC Davis, Apr-Jun 1993. Intensive instruction in marine ecology, biology, and physiology, conduct/present original research project
Cetacean Field Research, San Francisco State University, San Francisco, CA June 1990. Wildlands Studies Program including population and behavior assessment of St. Lawrence Estuary cetaceans using boat transects, tracking and photo identification techniques

AWARDS/ HONORS

Post-doctoral fellowship recipient: NOAA-OHHI Interdisciplinary Research and Training Initiative Coastal Ecosystems Human Health (I-RICH). June 2008-June 2009
Student Travel Award for IAAAM annual conference, May 2009
Recipient "Best presentation" award, IAAAM annual conference, May 2008.
Student Travel award for IAAAM annual conference, May 2008
Student Travel award for IAAAM annual conference, May 2007
Recipient: VSTP (dual DVM/PhD) Scholarship, School of Vet Medicine, University of California,Davis, 2001-2005

COMMUNITY SERVICE

Rhode Island State Science Fair Judge, Community College of Rhode Island 2008, 2009
Sonoma County Wildlife Rescue, Volunteer Veterinarian, Santa Rosa, CA. Jul 2005-Jun 2006. Care of injured and diseased wildlife, outreach and education of local rehabilitators and general public
Rural Area Veterinary Service (RAVS) volunteer. Palau, Micronesia June-July, 2005; Rosebud, SD, March 2003; Covelo, CA, November 2003 and February 2004. Free spay, neuter, vaccination and general medicine clinics in low income regions (national and international trips), as well as outreach and education of animal health
The Marine Mammal Center Animal Care Crew Volunteer, Sausalito, CA. July 1998- June 2005. Care and rehabilitation of injured/diseased marine mammals and sea turtles, stranded animal response, rescue and necropsy, education and outreach with general public (Sunday Day Crew)
Mercer Clinic volunteer, Sacramento, CA. 2001-2003. Free veterinary clinic for homeless pets

SCHOLARLY SERVICE: Reviewer for the following journals: Marine Mammal Science, Aquatic Mammals, Research in Veterinary Science, Journal of Wildlife Diseases, Veterinary Record, Journal of Zoo and Wildlife Medicine, Zoo Biology
MEMBERSHIPS: International Association for Aquatic Animal Medicine (IAAAM); Society for Marine Mammology (SMM); American Association of Zoo Veterinarians (AAZV); American Veterinary Medical Association (AVMA)

PUBLICATIONS

Greig DJ, Gulland FM, Smith WA, Conrad PA, **Field CL**, Fleetwood M et al. 2014 Surveillance for zoonotic and selected pathogens in harbor seals Phoca vitulina from central California. Dis Aqua Org 111:93-106
Jones K, **Field CL**, MacLean R, Stedman N. 2014. Cloacolithiasis and intestinal lymphosarcoma in an African black-footed penguin. J Zoo Wildl Med 45(2)446-9
MacLean R, Beaufrere H, Heggem-Perry B, **Field C**, Garner, M. 2013. Presumed reactive polyarthritis and granulomatous vasculitis in a Mississippi Sandhill Crane (Grus canadensis pulla). J Avian Med Surg 27(4): 309-314
Field CL, Beaufrere H, Wakamatsu N, Rademacher N, MacLean R. (2012) Discospondylitis caused by *Staphylococcus aureus* in an African Black-footed penguin (*Spheniscus demersus*). 2012, J Avian Med Surg 26(4).
Meegan J, Sidor, IF, **Field, C**, Roddy, N, Sirpenski, G, Dunn, JL. (2012). Endoscopic evaluation and biopsy collection of the gastrointestinal tract in the green moray eel (Gymnothorax funebris): application in a case of chronic regurgitation with gastric mucus gland hyperplasia. J Zoo Wildl Med 43(3):615-20
Field CL, Tablin F. (2012). Response of Northern Elephant Seal platelets to pressure and temperature changes: A comparative study with human platelets. Comp Biochem Physiolo A. Mol Integr Physiol 162(4) 289-95.
Biancani B, **Field, CL**, Dennison S, Pulver, R, Tuttle, AD. (2012) Hiatal hernia in a harbor seal pup. J Zoo Wildl Med 43:355-9.
Field CL, Tuttle AD, Sidor IF, Meegan J, Gilbert-Marcheterre K, Risatti G, Nyaoke A, Deering KM, Frasca S, Dunn JL. (2012). Systemic mycosis in a California sea lion (*Zalophus californianus*) with detection of cystofilobasidiomycete DNA. J Zoo Wild Med 43(1):144-152.
Goldstein T, Gill VA, Tuomi P, Monson D, Burdin A, Conrad PA, Dunn JL, **Field C**, Johnson C, Jessup DA, Estes JA, Bodkin J, Doroff AM. (2011) Assessment of clinical pathology and pathogen exposure in sea otters (*Enhydra lutris*) bordering the threatened population in Alaska. J Wildl Dis 47(3):579-92

Meegan J, **Field C**, Sidor I, Romano T, Casinghino S, Smith CR, Kashinsky L, Fair PA, Bossart G, Wells R, Dunn JL. (2010) Development, validation and utilization of a competitive enzyme-linked immunosorbent assay for the detection of antibodies against Brucella species in marine mammals. J Vet Diagn Invest 22(6):856-62

Ferreira CM, **Field, CL**, Tuttle, AD. (2010) Hematological and plasma biochemical parameters of aquarium-maintained cownose rays. Journal of Aquatic Animal Health 22:123-128, 2010

Goldstein T, Stephens CA, Jang SS, Conrad PA**, Field C**, Dunn JL, Mellish JE. (2007) Longitudinal Health and Disease Monitoring in Juvenile Steller Sea Lions (*Eumetopias jubatus*) in Temporary Captivity in Alaska Compared with a Free-Ranging Cohort. Aquatic Mammals 33:337-348

Gousset K, Wolkers WF, Tsvetkova NM, Oliver AE, **Field CL**, Walker NJ, Crowe JH, and Tablin F. (2002) Evidence for a physiological role for membrane rafts in human platelets. J Cell Physiol 190: 117-128

Field CL, Walker NJ, Tablin F. (2001) Northern Elephant seal platelets: Analysis of shape change and response to platelet agonists. Thromb Res 101: 267-277

Tsvetkova NM, Walker NJ, Crowe JH, **Field CL**, Tablin F. (2000) Lipid phase separation correlates with activation in platelets during chilling. Molec Memb Biol 17: 209-218

Tablin F, Walker NJ, **Field CL**, Crowe JH. (2000) Animal models for studies on cold-induced platelet activation in human beings. J Lab Clin Med 135: 339-346

Wun T, Paglieroni T, **Field CL**, Welborn J, Cheung A, Walker NJ, Tablin F. (1999) Platelet-erythrocyte adhesion in sickle cell disease. J Invest Med 47(3): 121-127

Tablin F, Rabier MJ, Walker NJ, Velasco VM, **Field CL**, Leven RM. (1998) Tenascin-C is synthesized and secreted by megakaryocytes, whose adherence to intact tenascin is mediated by the integrin 8:142-149

Wun T, Paglieroni T, Cordoba M, Welborn J, Rangaswami A, **Field C**, Cheung A, Tablin F. (1997) Intracellular tumor necrosis factor--with sickle cell disease. Blood 90, suppl 1(2):2835

PRESENTATIONS

39th Annual Eastern Fish Health Workshop, April 2014. Title: The EPO Depot: Anemia and blood transfusions elasmobranchs

IAAAM 44th Annual Conference, April, 2013. Title: Effects of propofol anesthesia on bonnethead (Sphyrna tiburo) and sandtiger (Carcharias Taurus) shark cardiorespiratory and blood gas parameters.

Effects of Oil on Wildlife Conference, January, 2012. Title: Intake and treatment of oiled sea turtles in Louisiana during the 2010 BP Deepwater Horizon oil spill.

IAAAM 42nd Annual Conference, May 2011. Title: Intake and treatment of oiled sea turtles in Louisiana during the 2010 BP Deepwater Horizon oil spill.

2nd Annual Wisconsin Exotic and Zoo Animal Medicine Club Symposium invited speaker: Nov. 2009. Title: Marine Brucella Diagnostics and Emerging Diseases.

IAAAM 40th Annual Conference, May 2009. Title: Intracellular Cytopathic Effects of Marine Brucella on Human and Beluga Monocytes.

34th Annual Eastern Fish Health Workshop, April 2009. Title: Effects of Carprofen on Cyclooxygenase Production by Blood Cells from the Cownose Ray.

37th Annual European Association for Aquatic Mammals Conference, March 2009. Title: Medical and Surgical Management of a Harp Seal with Pneumonia and Foreign Body Ingestion.

IAAAM 39th Annual Conference, May 2008. Title: Disseminated fungal infection in a California Sea Lion with detection of cystofilobasidiomycete DNA.

NOAA-OHHI Annual Primary Investigator Symposium, Michigan, Oct. 2007. Title: The impact of marine-origin Brucella on marine mammal and human health.

IAAAM 38th Annual Conference, May 2007. Presentation title: A Comparison of Marine-origin Brucella seroprevalence between 3 populations of sea otters.

Society for Marine Mammology 16th Biennial Meeting, December, 2005. Presentation title: Rapid decompression does not induce activation of Northern Elephant Seal platelets: A comparative study with human platelets

IAAAM 35th Annual Conference, April 2004. Presentation title: High Hydrostatic pressure significantly inhibits the rise in Northern Elephant Seal platelet calcium: A comparative study with human platelets.

IAAAM 34th Annual Conference, May 2003. Presentation title: Rapid decompression induces microvesiculation but not activation in Northern Elephant Seal platelets.

IAAAM 33rd Annual Conference, May 2002. Presentation title: Northern Elephant Seal Platelets are protected from platelet activation associated with rapid decompression.

Society for Marine Mammology 13th Biennial Meeting, November 1999. Presentation title: Ultrastructure and function of Northern Elephant Seal platelets.

Curriculum Vitae

JACK AMES
California Department of Fish and Wildlife, Office of Spill Prevention and Response
Marine Wildlife Veterinary Care and Research Center
151 McAllister Way, Santa Cruz, CA 95060
831.676.1191 (cell); 831.469.1723 (fax)
jack.ames@wildlife.ca.gov

EDUCATION

Bachelor of Science, Sacramento State College, June 1967

EMPLOYMENT HISTORY

July 1967-June 1972	CA Department of Fish and Game	Fisheries Biologist

Duties: monitoring albacore tuna fishery and assessing sportfish populations on manmade habitats

July 1972-Sept 2011	CA Department of Fish and Game	Sea Otter Biologist

Duties: participation in the design and construction of equipment used in three methods of sea otter capture, participation in the collection of dead sea otter carcasses, participation in sea otter necropsies, participation in twice annual sea otter counts, participation in studies to understand the accuracy of sea otter counts, participation in studies designed to understand the effect of various kinds of fishing gear on sea otter mortality, participation in the design, and construction and stockpiling of portable, floating, holding pens for potential use with oil-injured sea otters

October 2011-present	CA Department of Fish and Wildlife (Formerly CA Department of Fish and Game)	Retired Annuitant

Duties: assist with various sea otter research and conservation projects at the Marine Wildlife Veterinary Care and Research Center and various projects with collaborators

SELECT PUBLICATIONS

Wild, P.W., and **Ames, J.A.** (1974). A report on the sea otter, *Enhydra lutris L.*, in California. Marine Resources Technical Report No. 20, CDFG, 95pp.

Morejohn, G. V., **Ames, J. A.**, & Lewis, D. B. (1975). Post mortem studies of sea otters, *Enhydra lutris L.*, in California. Marine Resources Technical Report No. 30, CDFG, 87pp.

McCleneghan, K., & **Ames, J. A.** (1976). A unique method of prey capture by a sea otter, *Enhydra lutris*. *Journal of Mammalogy*, *57*(2), 410-412.

Ames, J. A., & Morejohn, G. V. (1980). Evidence of white shark, Carcharodon carcharias, attacks on sea otters, *Enhydra lutris*. *California Fish and Game*, *66*(4), 196-209.

Williams, T. D., Mattison, J. A., & **Ames, J. A.** (1980). Twinning in a California sea otter. *Journal of Mammalogy*, *61*(3), 575-576.

Ames, J. A., Hardy, R. A., & Wendell, F. E. (1986). A simulated translocation of sea otters, *Enhydra lutris*, with a review of capture, transport and holding techniques. Marine Resources Technical Report No. 52, CDFG, 17pp.

Faurot, E. R., **Ames, J. A.**, & Costa, D. P. (1986). Analysis of sea otter, *Enhydra lutris*, scats collected from a California haulout site. *Marine Mammal Science*, *2*(3), 223-227.

Wendell, F. E., Hardy, R. A., & **Ames, J. A.** (1986). An assessment of the accidental take of sea otters, *Enhydra lutris*, in gill and trammel nets. Marine Resources Technical Report No. 54, CDFG, 31pp.

Garshelis, D. L., **Ames, J. A.**, Hardy, R. A., & Wendell, F. E. (1990). Indices used to assess status of Sea Otter populations: a comment. *The Journal of wildlife management*, 260-269.

Bodkin, J. L., **Ames, J. A.**, Jameson, R. J., Johnson, A. M., & Matson, G. M. (1997). Estimating age of sea otters with cementum layers in the first premolar. *The Journal of wildlife management*, 967-973.

Estes, J., Hatfield, B. B., Ralls, K., & **Ames, J.** (2003). Causes of mortality in California sea otters during periods of population growth and decline. *Marine Mammal Science*, *19*(1), 198-216.

Jessup, D. A., Miller, M., **Ames, J.**, Harris, M., Kreuder, C., Conrad, P. A., & Mazet, J. A. (2004). Southern sea otter as a sentinel of marine ecosystem health. *EcoHealth*, 1(3), 239-245.

Miller, M. A., Byrne, B. A., Jang, S. S., Dodd, E. M., Dorfmeier, E., Harris, M. D., **Ames, J.A**.,... & Miller, W. A. (2010). Enteric bacterial pathogen detection in southern sea otters (*Enhydra lutris nereis*) is associated with coastal urbanization and freshwater runoff. *Veterinary research*, *41*(1), 1-13.

Young, C., Eguchi, T., **Ames, J.A**., Staedler, M., Hatfield, B. B., Harris, M., & Golson-Fisch, E.A. (2019). Drift and beaching patterns of sea otter carcasses and car tire dummies. *Marine Mammal Science* early access: DOI: 10.1111/mms.12609

Curriculum Vitae

NANCY L. ANDERSON, DVM, ABVP (Avian), PhD

Employment History

Dates	Institution	Position
2011-present	Oiled Wildlife Care Network	Field Veterinarian
2010-2011	Six Flags Discovery Kingdom	Staff Veterinarian
2000-2010	Lindsay Wildlife Museum	Director of Wildlife Services 2006-2009, Deputy Director
1997-2002	The Ohio State University	Graduate Research Associate Dept. Evolution, Ecology and Organismal Biology
1992-2000	The Ohio State University	Director Raptor Rehabilitation Program
1991-1997	The Ohio State University	Assistant Professor, Clinical 1992-1996, Director General Practice
1990-1991	Marysville Animal Care Center	Associate Veterinarian
1989	Harcourt Veterinary Clinic	Associate Veterinarian
1988	Relief Veterinarian	Veterinarian

Education

Date	Institution	Degree
2002	The Ohio State University	PhD: Ecophysiology
1994	American Board of Veterinary Practitioners	Avian Medicine Specialty
1989	The Ohio State University *cum laude* with University Honors	BS: Agricultural Engineering
1988	The Ohio State University *cum laude*	DVM

Professional Licenses

DEA: Controlled Substances Administration Certificate
California Veterinary Medical Board
Ohio Veterinary Medical Board
USDA Accredited

Educational Awards

Raymond C. Osburn Memorial Graduate Fellowship
Phi Zeta Veterinary Honor Society
Alpha Epsilon Agricultural Honor Society

Tau Beta Pi Engineering Honorary
Women in Engineering Award
Ford Motor Company Women in Engineering Award
Caterpillar Tractor Company Women in Engineering Award
Chimes Junior Honor Society
Romophos Sophomore Honor Society
Freshman Scholar, The Ohio State University
Alpha Lambda Delta, Freshman Honor Society
Phi Eta Sigma, Freshman Honor Society
National Council of Teachers of English Achievement Award in Writing

General Fields of Interest

Working with colleagues to develop innovative and effective solutions to challenges encountered when working with wildlife, exotic animals and domestic species. My interests range from individual animals to a population level.

Develop and implement presentations and materials that provide staff, students, and the general public with the information/training necessary to understand fundamental concepts pertinent to the task/topic at hand and to perform their work with thoughtful attention and enthusiasm.

Backpacking, canoeing, bird watching, SCUBA diving, ballroom dancing

Teaching Experience

Department of Medicine and Epidemiology: University of California, Davis

Zoological Avian Medicine, Avian Physiology, Avian Neurology, Field Techniques for Assessment of Wildlife and Ecosystems, Reptile Handling Laboratory, Reptile Nutrition, Health & Disease in Terrestrial Wildlife

Department of Evolution, Ecology, and Organismal Biology: The Ohio State University

Dynamics of the Dinosaurs, Vertebrate Dissection Laboratory, Evolution, Introduction to Ecology Laboratory and Lecture

Department of Veterinary Clinical Sciences: The Ohio State University

Senior General Practice Clinical Rotation, Non-mammalian Core Curriculum, Avian Medicine, Advanced Avian Medicine, Reptile Medicine, Small Mammal Medicine, Veterinary Population Medicine, Raptor Medicine, Animal Behavior

Service Work

2018	Reviewer Marine Ornithology
2016	Proceedings Reviewer for Arctic Marine Oil Pollution Conference
2012 to present	Manage and advisor for the Phil and Karen Drayer Wildlife Health Center Fellowship Award.
2014 to present	Teach avian skills wetlab for UC Davis veterinary students: Wildlife and Aquatic Medicine Club

2013-2014	Member Disaster Preparedness Committee for the American Association of Zoo Veterinarians
2011	Author Sea Turtle Fibropapilloma article for Infectious Disease Committee for American Association of Zoo Veterinarians
2006– 2010	Department of Fish and Game Task Force to investigate emerging diseases in great grey owls in the Yosemite region.
2004 – 2010	Member Scientific Advisory Board: Oiled Wildlife Care Network
2001 – 2010	Mentor Lindsay Wildlife Museum veterinary student externships
2007-2009	Associate Editor for Journal of Zoo and Wildlife Medicine
2007	Member American Association of Wildlife Veterinarians Ad Hoc Policy Committee on Communications Strategies
2005-2006	Co-author rodent and small mammal section for Guidelines for Euthanasia of Nondomestic Animals published by the Association of Zoo Veterinarians
2000 – 2001	Associate Editor, Reptile Section of Petplace.com
1998 – 2002	Associate Editor, Medicine Section for the Journal of Reptile and Amphibian Medicine and Surgery
1998 – 1999	Seminar Speaker Chair for Evolution and Ecology Grad Students
1998 – 1999	Local host for ARAV/AAZV Annual Meeting
1997 – 2000	Volunteer mentor for OSU Raptor Rehabilitation Program
1996 - 1997	Co-chair 21st OSU/Waltham Symp on Exotic Animal Medicine
1996 - 1999	American Board of Veterinary Practitioners Avian Core Examination Committee
1996 - 1999	Consulting Co-editor Current Veterinary Therapy XIII Diseases of Birds and Exotic Pets Section
1996	Reviewer Manual of Raptors, Pigeons, and Waterfowl, Iowa State University Press
1996	Reviewer Client Information Series, Veterinary Practice Publishing Company
1995	Reviewer for Biology of the Reptilia, Academic Press
1993 – 1994	OSU: Non-mammalian species core course planning committee
1991 - present	Association of Avian Veterinarians Student Chapter Committee (1991 - 1997) University Curriculum Committee (1991 - 1997)
1991 – 1997	OSU: Advisor Student Chapter AAZV/AAV
1991 – 1997	OSU: Advisor to students on Academic Probation

Professional/Academic Association Memberships

1988 - present	American Veterinary Medicine Association
1988 - present	Association of Avian Veterinarians
1994 - present	American Board of Veterinary Practitioners
2000 – present	American Association of Zoo Veterinarians
2000 – present	California Veterinary Medical Association
2004 – present	Wildlife Disease Association

2000 - 2012	American Association of Wildlife Veterinarians
2000 - 2012	International Wildlife Rehabilitations Council
1991 - 2012	National Wildlife Rehabilitators Association

Pertinent Recent Veterinary Continuing Education

2017	American Association of Zoo Veterinarians Annual Meeting
2016	National Animal Health & Stranding network Conference
2016	Project Management Course
2016	Teaching and Learning in the Clinical Setting
2016	Atlantic Coast Veterinary Conference
2010-15, 2004 –08	American Association of Zoo Veterinarians Annual Meeting
2011	Shark Reef Aquatic Animal Medicine Seminar
2011	USDA workshop: Tuberculosis in elephants
2010, 2007, 2005	Association of Avian Veterinarians Annual Meeting
2009 - 2016	24 hour HAZWOPER (refresher)
2005, 2006, 2009	Annual UC Davis WAAM Wildlife Medicine Symposium
2005	CDFG Advanced Chemical Immobilization Course
2004, 2005	California Council for Wildlife Rehabilitators Annual Symposium
2004	CDFG HAZCOM Course: 1001
1999	GIS and Remote Sensing for Wildlife Managers, Smithsonian Institution

Publications

Refereed Journals

2011. Siembieda JL, Miller WA, Byrne BA, Ziccardi MH, Anderson N, Chouicha N, Sandrock CE, Johnson CK. Zoonotic pathogens isolated from wild animals and environmental samples at two California wildlife hospitals. J Am Vet Med Assoc. 238(6): 773-83.

2010. Anderson NL, Johnson CK, Fender S, Heckly S, Metzler M, Nave P, Yim J. Clinical signs and histopathologic findings associated with a newly recognized protozoal disease (Trichomonas gallinae) in free-ranging house finches (Carpodacus mexicanus). J Zoo Wild Med. 41(2): 249-254.

2010, Ley DH, Anderson N. Dhondt KV, Dhondt AA. Mycoplasma sturni from a California House Finch with conjunctivitis did not cause disease in experimentally infected House Finches. J Wildl Dis. 46(3): 994-9.

2009. Anderson NL, Grahn RA, Van Hoosear KA, BonDurant RH. Studies of trichomonad protozoa in free ranging songbirds: Prevalence of Trichomonas gallinae in house finches (Carpodacus mexicanus) and corvids and a novel trichomonad in mockingbirds (Mimus polyglottos). Vet Parasitol 161: 178-186.

2009. Anderson NL. Late Stage Granulomatous Interstitial Pneumonia Secondary to Near-drowning in an Osprey (Pandion haliaetus). J Wildl Rehab: 29: 10-21.

2008. Hetherington TE, Coupe B, Perry G, Anderson N, Williams JB. Diurnal refuge-site selection by Brown Treesnakes (Boiga irregularis) on Guam. Amphib Rept: 29(2): 284-287.

2008. Ishak HD, Dumbacher JP, Anderson NL, Keane JJ, Valkiunas G, Haig SM, Tell LA, Sehgal NM. Blood parasites in owls with conservation implications for the spotted owl (Strix occidentalis). PLoS ONE 3(5): e2304. doi:10.1371/journal.pone.0002304.

2007. Anderson NL. Sporotrichosis in a broad-footed mole (Scapanus latimanus), a zoonotic disease. J Wildl Rehab 28: 18-21.

2007. Padgett KA, Reisen WK, Kahl-Purcell N, Fang Y, Cahoon-Young B, Carney R, Anderson N, Zucca L, Woods L, Husted S, Kramer V. West Nile infection in tree squirrels (Rodentia: Sciuridae) in California, 2004-2005. Am J Trop Med Hyg: 76: 810-813.

2006. Anderson NL. Clostridial enteritis in a mallard duck (Anas platyrhynchos). J Wildl Rehab 28: 4-12.

2006. Sehgal RNM, Hull AC, Anderson NL, Valkiunas G, Markovets MJ, Kawamura S, Tell L. Evidence for cryptic speciation of Leucocytozoon spp. (Haemosporida, Leucocytozoidae) in diurnal raptors. J Parasitol 92: 375-379.

2005. Anderson NL, Hetherington TE, Coupe B, Perry G, Williams J, Lehman J. Thermoregulation in a nocturnal, tropical, arboreal snake. J Herp 39: 82-90.

2004. Wack RF, Anderson NL. Resuscitation of a Hispaniolan slider (Trachemys decorata) using Oxyglobin and a blood transfusion. J Herp Med Surg 14: 4-5.

2003. Anderson NL, Hetherington TE, Williams JB. Validation of the doubly labeled water method under low and high humidity to estimate metabolic rate and water flux in a tropical snake (Boiga irregularis). J Appl Physiol 95: 184-191.

2000. Anderson NL, Coupe B, Perry G, Hetherington TE, Williams JB. Field use of propofol: a rapid recovery anesthetic with data from brown treesnakes (Boiga irregularis). Herp Rev 30: 161-163.

1999. Anderson NL, Wack RF, Calloway L, Hetherington TE, Williams JB. Cardiopulmonary effects and efficacy of propofol as an anesthetic agent in brown treesnakes, Boiga irregularis. Bull Assoc Rept Amphib Vet 9(2): 9-15.

1997. Anderson NL, Wack RF, Hatcher R. Hematology and clinical chemistry reference ranges for clinically normal, captive New Guinea snapping turtle (Elseya novaeguineae) and the effects of temperature, sex, and sample type. J Zoo Wildl Med 28(4): 394-403.

1997. Anderson NL. Recurrent deep foreign body granuloma in the tongue of an African Grey Parrot (Psittacus erithacus timneh). J Avian Med Surgery 11(2): pp. 105-109.

1997. Anderson NL. Editorial: The need to teach exotic animal medicine in veterinary schools. J Avian Med Surgery 11(2): p. 75.

1996. Anderson NL, Williams J, Sagartz J, Barnewell, R. Ovarian teratoma in Iguana iguana. J Zoo Wildl Med 27(1): 90-95.

1994. Wack RF, Kramer LW, Anderson NL. Cardiomegaly and endocardial fibrosis in a secretary bird (Sagittarius serpentarius). JAAV 8(2): 76-80.

1993. Anderson NL. Candida/megabacteria proventriculitis in a Lesser Sulfur Crested Cockatoo (Cacatua sulphurea sulphurea). JAAV 7(4):197-201.

1992. Anderson NL. Diseases of Iguana iguana.: Compend Contin Educ Prac Vet 14(10): 1335-1343.

1991. Anderson NL. Husbandry and clinical evaluation of Iguana iguana.: Compend Contin Educ Prac Vet 13(8): 1265-1272.

Book Chapters/Proceedings/Posters (not listed under presentations)

2006. McClure D, Anderson NL. Rodents and small mammals. In: Guidelines for Euthanasia of Nondomestic Animals. Association of Zoo Veterinarians Pp. 61-65.

2006. Anderson NL. Pet rodents. In Birchard SJ, Sherding RG eds.: Saunders Manual of Small Animal Practice 3rd ed. Philadelphia: W.B. Saunders, pp. 1881-1909.

2006. Anderson NL, Wack RF. Basic husbandry and medicine of pet reptiles. In Birchard SJ, Sherding RG eds.: Saunders Manual of Small Animal Practice 3rd ed. Philadelphia: W.B. Saunders, pp. 1910-1942.

2005. Padgett KA, Reisen W, Cahoon-Young B, Carney L, Woods L, Zucca L, Anderson N, Husted S, Kramer V. West Nile virus infection in tree squirrels (Rodentia: Sciuridae) in California, 2004-2005. Poster 4th International Congress of Vector Ecology.

2004. Zabka TS, Andersen AA, Leutenegger CM, Anderson NL, Tell LA, Johnson SP, Lowenstine, LJ. A new strain of Chlamydiophila psittaci, Strain G, isolated from red tailed hawks (Buteo jamaicensis): Identification, prevalence, diagnostic testing, and pathology. 2004 Proceedings AAZV, AAWV, WDA Joint Conference, 440-444.

2000. Anderson NL, Wack RF. Anesthetic procedures in exotic pets. In Muir W, Hubbell J eds.: Handbook of Veterinary Anesthesia 3rd ed. St. Louis: C.V. Mosby Company, pp. 372-408.

2000. Anderson NL. Pet rodents. In Birchard SJ, Sherding RG eds.: Saunders Manual of Small Animal Practice 2nd ed. Philadelphia: W.B. Saunders, pp. 1512-1538.

2000. Anderson NL, Wack RF. Basic husbandry and medicine of pet reptiles. In Birchard SJ, Sherding RG eds.: Saunders Manual of Small Animal Practice 2nd ed. Philadelphia: W.B. Saunders, pp. 1539-1567.

1999. Miller RE, Anderson NL. Immunization of wild animal species against common diseases. In Bonagura JD (ed.): Current Veterinary Therapy XIII. Philadelphia: W.B. Saunders Co..

1997. Anderson NL. Diseases of Iguana iguana. In Rosenthal K ed.: Exotic Animal Medicine in Practice. Trenton, New Jersey: Veterinary Learning Systems, pp.14-19.

1997. Anderson NL. Husbandry and clinical evaluation of Iguana iguana. In Rosenthal K ed.: Exotic Animal Medicine in Practice. Trenton, New Jersey: Vet Learning Sys, pp. 20-26.

1997. Anderson NL. Case studies. In Rosenthal K, Brown S ed.: Self-Assessment Colour Review of Small Mammals. London: Manson Publishing Ltd., pp. 5,6,9,10,21,22,45,46,49,50.

1995. Anderson NL. Intraosseous fluid therapy in small exotic animals. In Bonagura JD, Kirk RW eds.: Kirk's Current Veterinary Therapy XII. Philadelphia: W.B. Saunders Company, pp. 1331-1335.

1995. Anderson NL, Wack RF. Anesthetic procedures in exotic pets. In Muir W, Hubbell J eds.: Handbook of Veterinary Anesthesia. St. Louis: C.V. Mosby Company, pp. 341-371.

1994. Anderson NL. Basic husbandry and medicine of pocket pets. In Birchard SJ, Sherding RG eds.: Saunders Manual of Small Animal Practice. Philadelphia: W.B. Saunders, pp. 1363-1389.

Professional Presentations

2015. Anderson NL. Field Stabilization Program Can Enhance Survival of Seabirds During Oil

Spill Response. 2015 Proc. Effects of Oil on Wildlife Conf., Anchorage, AK Pp. 17-31.

2014. Anderson NL. Development of Field Stabilization Program to Enhance Survival of Seabirds During Oil Spill Response. 2014 Proc. International Oil Spill Conf., Savannah, GA Pp. 1545-1558.

2012. Anderson, NL, Ziccardi M. Oiled Wildlife Care Network: A Public, private, not-for-profit partnership. Environmental Response to Oil Spills in California (EROS) Training. Monterey Bay CA.

2009. Anderson NL, Grahn RA, Van Hoosear KA, BonDurant RH. Clinicopathologic features of trichomonad infections in free ranging finches, mockingbirds, and corvids in northern California. UC Davis 15th Annual WAAM Wildlife Medicine Symposium.

2009. Anderson NL. Late Stage Granulomatous Interstitial Pneumonia Secondary to Near-drowning in an Osprey (Pandion haliaetus) UC Davis 15th Annual WAAM Wildlife Medicine Symposium.

2008. Anderson NL, Grahn RA, Van Hoosear KA, BonDurant RH. Avian trichomoniasis. AAZV, Los Angeles, CA

2007. Anderson NL. Wildlife rehabilitation. California State University, Concord, CA

2006. Anderson NL. Dealing with head trauma in wildlife. Ross Veterinary School, St. Kitts

2006. Anderson NL. Amphibian diseases. Ross Veterinary School, St. Kitts

2006. Anderson NL. Reptile diagnostic techniques. Ross Veterinary School, St. Kitts

2006. Anderson NL. West Nile Virus: A wildlife rehabilitation vet's clinical experience. UC Davis 12th Annual WAAM Wildlife Medicine Symposium.

2005. Anderson NL, Whited, L. Pain management. California Council of Wildlife Rehabilitators Annual Meeting. Reading, CA.

2005. Anderson NL. Dealing with head trauma. California Council of Wildlife Rehabilitators Annual Meeting and Region 3 Meeting California Department of Fish and Game.

2004. Anderson NL. Use of antibiotics in wildlife. California Council of Wildlife Rehabilitators Annual Meeting. Yosemite, CA.

2002. Anderson NL. Trichomonas in house finches and corvids in the East Bay area of California. Proc International Wildlife Rehabilitators Council. Concord, CA.

2002. Anderson NL. Avian hematology. Proc International Wildlife Rehabilitators Council. Concord, CA.

2002. Anderson NL. Avian radiology. Proc International Wildlife Rehabilitators Council. Concord, CA.

2000. Anderson NL, Hetherington T, Williams J. Indirect calorimetry studies of brown treesnakes (Boiga irregularis) at 20 C, 25 C, 30 C, and 35 C. ASIH, SSAR, HL AES, NIA, and CAH Annual Meeting. La Paz, Mexico.

2000, 1999. Anderson NL. Reptile Medicine Series. Purdue University College of Veterinary Medicine, Lafayette, Indiana

1999. Anderson NL. The brown tree snake dilemma. The Kansas City Herpetological Society, Kansas City, Missouri

1998. Anderson NL, Hetherington T, Coupe B, Perry G, Williams J. Field and laboratory studies of temperature and water balance physiology of the brown treesnake: I. Temperature preferences and temperature characteristics of refugia. 1998 Brown treesnake Research

Symposium. Honolulu, HI, p. 9.
1998. Anderson NL, Hetherington T, Williams J, Coupe B, Perry G. Field and laboratory studies of temperature and water balance physiology of the brown treesnake: II. Water flux rates and susceptibility to desiccation. 1998 Brown treesnake Research Symposium. Honolulu, HI, p. 9.
1998. Anderson NL, Wack RF, Burke L, Hetherington T, Williams J. Assessment of propofol as an anesthetic agent in brown treesnakes, Boiga irregularis. Proc 5th Annual Conf Assoc Reptilian and Amphibian Veterinarians. Kansas City, MO, pp. 29 – 31.
1998. Perry G, Coupe B, Anderson N, Hetherington T. Daily refugia of brown tree snakes on Guam: location choice and thermal implications. Proc ASIH, SSAR, HL AESAM and Canadian Assoc. Herpetologists Annual Meeting. Guelph, Canada, p. 585.
1998. Anderson NL, Coupe B, Perry G, Hetherington T, Williams J. Field and laboratory studies on active and resting body temperatures of a nocturnal, tropical snake (Boiga irregularis). Proc ASIH, SSAR, HL, AESAM, and Canadian Assoc. Herpetologists Annual Meeting. Guelph, Canada, p. 461.
1998. Anderson NL, Coupe B, Hetherington T, Williams J. Field use of propofol: Finally a safe, effective, rapid recovery anesthetic for reptiles. Proc ASIH, SSAR, HL, AESAM, and Canadian Assoc. Herpetologists Annual Meeting. Guelph, Canada, p. 506.
1997. Anderson NL. Exotic animal medicine series. Tokyo and Osaka, Japan.
1995, 1993. Anderson NL and Wack RF. Avian hematology laboratory and wildlife rehabilitation assistance. Guatemala City, The Peten region, and the Pacific coast region, Guatemala.
1997. Anderson NL. Use of intraosseous fluids in wildlife rehabilitation. 1997 Annual Proceedings of the National Wildlife Rehabilitators Association. Columbus, Ohio.
1996. Anderson, NL. The Effects of Temperature, Sex, and Sample Type on Hematology and Serum/Plasma Chemistry Values for Captive New Guinea Snapping Turtles (Elseya novaeguineae). Annual Proceedings of the Association of Reptilian and Amphibian Veterinarians. Tampa, Florida. Pp. 43 - 50.
1996. Anderson, NL. Ovarian Teratoma in a Green Iguana (Iguana iguana). Annual Proceedings of the Association of Reptilian and Amphibian Veterinarians. Tampa, Florida. Pp. 127 - 130.
1996. Anderson, NL. Intraosseous fluid therapy. Annual Proceedings of OVMA. Columbus, Ohio
1996. Anderson, NL. Rabbit/ ferret behavior. Annual Proceedings of OVMA. Columbus, Ohio.
1996. Anderson, NL. Diseases of iguanas. Annual Proceedings of OVMA. Columbus, Ohio.
1996. Anderson, NL. Anorexia in reptiles. Annual Proceedings of OVMA. Columbus, Ohio.
1995. Anderson, NL. Avian hematology and serum chemistry. An Proc of AAV: Introduction to Clinical Avian Medicine Proceedings. Philadelphia, Pennsylvania. P. 47-57.
1995. Anderson, NL. Avian Radiology. Annual Proceedings of WEZAM. Madison, Wisconsin.
1995. Anderson, NL. Avian Dermatology. Annual Proceedings of WEZAM. Madison, WI.
1995. Anderson, NL. Basic Avian Techniques. Annual Proceedings of WEZAM. Madison, WI.
1995. Anderson, NL. Head trauma in wildlife. Proc OWRA Annual Meeting. Columbus, OH.
1994. Anderson, NL. Successful treatment of urolithiasis associated with a fungal cystitis in Iguana iguana. Annual Proceedings of ARAV/AAZV. Pittsburg, PA. Pp. 52 - 56.
1993. Anderson NL. Stabilization of wildlife species. Proc OWRA An Meeting. Columbus, OH.

1992. Anderson, NL. Exotic Animal Anesthesia. Proceedings OSU Anesthesia Short course. Columbus, OH.
1991. Anderson, NL. Feather Picking. Midwest Avian Research Expo. Cleveland, OH. P. 74-83.

Research Funding

Effects of glucose and gavage temperature on warming of hypothermic seabirds
Oiled Wildlife Care Network
Status: Principle Investigator
Amount: [redacted]
Start date: October 2014 End date: June 2017

Ecophysiological studies of brown treesnakes
Biological Resources Division of United States Geological Service and
The Kansas City Herpetological Society Research Grant
Status: Co-Investigator
Principle Investigator: Thomas E. Hetherington PhD
Amount: $[redacted]
Start date: July 1997 End date: September 2000

Calcium-Regulating Hormones and Bone Remodeling in Green Iguanas (Iguana iguana)
Columbus Zoo/Ohio State University Co-operative Research Grant Program
Status: Co-Investigator
Principle Investigator: Thomas J. Rosol, DVM, PhD
Amount: $[redacted]
Start date: July 1997 End date: June 1998

Hematology and serum/plasma chemistry normals for captive Elseya novaguineae
(The New Guinea snapping turtle) held at 75 F and 85 F
Columbus Zoo Research Grant Program: Animal Management Health and
Scientific Studies Committee
Principal investigator: Nancy Anderson, DVM, ABVP (Avian)
Amount: $[redacted]
Start date: June 1994 End date: June 1995

Clinical Field Trial of Chewable Milbemycin
Ciba-Geigy Animal Health
Principal investigator: Nancy Anderson, DVM
Amount: $[redacted]
Start date: January 1993 End date: January 1994

CURRICULUM VITAE

BRIAN BOYCE HATFIELD

USGS – WERC
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Piedras Blancas Light Station Office
P.O. Box 70
San Simeon, CA 93452
Phone: (805) 305-2121

EDUCATION

1977 – 1979	California Polytechnic State University San Luis Obispo, California Master of Science in Biology, August 1979
1971 – 1975	University of California, Santa Cruz Bachelor of Arts, June 1975 Graduation with Honors in Biology

EXPERIENCE

Wildlife Biologist California Sea Otter Project October 1990 – Present	U.S. Geological Survey Piedras Blanc Office, Santa Cruz Field Station P.O. Box 70 San Simeon, CA 93452 (805) 927-3893
Biological Technician California Sea Otter Project January 1987 – October 1990	U.S. Fish and Wildlife Service Piedras Blancas Field Station P.O. Box 70 San Simeon, CA 93452 (805) 927-3893
Sea Otter Research Technician June 1984 – March 1987	Dr. Don Siniff University of Minnesota Piedras Blancas Field Station P.O. Box 70 San Simeon, CA 93452 (805) 927-5480
Biologist, Consultant October 1984 – April 1985	Marine Mammal Commission 1625 Eye Street, NW, Rm. 307 Washington, D.C. 20006 (202) 653-6237
Fish and Wildlife Seasonal October 1983 – June 1984	California Dept. of Fish and Game 213 B Beach Street Morro Bay, CA 93442

	(805) 772-3011
Biologist, Consultant February – July 1983	California Dept. of Fish and Game Diablo Canyon Ecological Studies P.O. Box 98, Avila Beach, CA 93424 (805) 595-7363
Junior College Instructor August 1982 – May 1983	Allan Hancock College 800 South College Drive Santa Maria, CA 93454 (805) 922-6966
Fish and Wildlife Seasonal March – December 1982	California Dept. of Fish and Game Diablo Canyon Ecological Studies P.O. Box 98, Avila Beach, CA 93424 (805) 595-7363
Fisheries Technician July – November 1980 & 1981	Pacific Marine Fisheries Commission c/o California Dept. of Fish and Game 213 B Beach Street Morro Bay, CA 93442 (805) 772-3011
Marine Biology Instructor February – June 1981	Catalina Island Marine Institute P.O. Box 796 Avalon, CA 90794 (213) 510-1622
Fish and Wildlife Seasonal December 1979 – June 1980	California Dept. of Fish and Game 213 B Beach Street Morro Bay, CA 93442 (805) 772-3011
Sea Otter Field Biologist July – December 1978	Dr. Aryan Roest Biological Sciences Department California Polytechic State University San Luis Obispo, CA (805) 546-2788

SPECIAL SKILLS

1982 Specialty Diver Certification, California Department of Fish and Game

1984 Training in underwater capture of sea otters, Calif. Dept. Fish and Game

1990 Closed circuit oxygen rebreather certification

PUBLICATIONS

HATFIELD , B.B., J.L. YEE, M.C. KENNER, J.A. TOMOLEONI, AND M.T. TINKER , 2018, California sea otter(*Enhydra lutris nereis*) census results, spring 2018: U.S. Geological Survey Data Series 1097, 10 p., https://doi.org/10.3133/ds1097

TINKER, M.T. AND B.B. HATFIELD. 2017, California sea otter (Enhydra lutris nereis) census results, spring 2017: U.S. Geological Survey Data Series 1067, 9 p., https://doi.org/10.3133/ds1067.

HATFIELD, B.B. AND P. UNITT. 2017. Southern sea otter, Enhydra lutris nereis. Pages 306-307 in Tremor, S., D. Stokes, W. Spencer, J. Diffendorfer, H. Thomas, S. Chivers, and P. Unitt, editors. San Diego County Mammal Atlas. Proceedings of the San Diego Society of Natural History 46.

TINKER, M.T. AND B.B. HATFIELD. 2016, California sea otter (*Enhydra lutris nereis*) census results, spring 2016: U.S. Geological Survey Data Series 1018, 10 p., http://dx.doi.org/10.3133/ds1018

TINKER, M.T., B.B. HATFIELD, M.D. HARRIS, and J.A. AMES. 2015. Dramatic increase in sea otter mortality from white sharks in California: Marine Mammal Science, v. 32, no. 1, p. 309–326, doi:10.1111/mms.12261.

LOWRY, M.S., R.CONDIT, B.B. HATFIELD, S.G. ALLEN, R. BERGER, P.A. MORRIS, B.J. LeBOEUF, AND J. REITER. 2014. Abundance, Distribution, and Population Growth of the Northern Elephant Seal (*Mirounga angustirostris*) in the United States from 1991 to 2010**.** *Aquatic Mammals* 2014, *40*(1), 20-31, DOI 10.1578/AM.40.1.2014.20

KENNER, M.C., J.A. Estes, M. TIM TINKER, J.L. BODKIN, R.K. COWEN, C. HARROLD, B.B. HATFIELD, M. NOVAK, A. RASSWEILER, and D.C. REED. 2013. A multi-decade time series of kelp forest community structure at San Nicolas Island, California (USA). Ecology 94:2654. http://dx.doi.org/10.1890/13-0561.1

HATFIELD, B.B., J.A. AMES, J.A. ESTES, M.T. TINKER, A.B. JOHNSON, M.M. STAEDLER, AND M.D. HARRIS. 2011. Sea otter mortality in fish and shellfish traps: estimating potential impacts and exploring possible solutions. Endangered Species Research 13(3):219-229

MILLER, M.A.., P.A. CONRAD, M. HARRIS, B. HATFIELD, G. LANGLOIS, D.A. JESSUP, S.L. MAGARGAL, A.E. PACKHAM, S. TOY-CHOUTKA, A.C. MELLI, M.A. MURRAY, F.M. GULLAND, AND M.E. GRIGG. 2010. A protozoal-associated epizootic impacting marine wildlife: mass-mortality of southern sea otters (Enhydra lutris nereis) due to Sarcocystis neurona infection. Veterinary Parasitology 172:183-197.

TINKER, M. T., D. F. DOAK, J. A. ESTES, B. B. HATFIELD, M. M. STAEDLER, AND J.L. BODKIN. 2006. Incorporating diverse data and realistic complexity into demographic estimation procedures for sea otters. Ecological Applications 16(6):2293-2312.

HATFIELD, B. B. 2005. The translocation of sea otters to San Nicolas Island: an update. Pp.473-475 in D.K. Garcelon and C.A. Schwemm eds., Proceedings of the Sixth California Islands Symposium, Ventura, California, December 1-3, 2003.

ESTES, J. A., B. B. HATFIELD, K. RALLS, AND J. AMES. 2003. Causes of mortality in California sea otters during periods of population growth and decline. Marine Mammal Science 19:198-216.

RATHBUN, G. B., B. B. HATFIELD, AND T. G. MURPHEY. 2000. Status of translocated sea otters at San Nicolas Island. The Southwest Naturalist 45(3).

HATFIELD, B. B. 2000. Southern sea otter population status update. Pacific Cetacean Group Newsletter, U.C. Monterey Bay, 3239 Imjin Road, #122, Marina CA 93933.

HATFIELD, B. B. AND G. B. RATHBUN. 1999. Interactions between northern elephant seals and vehicles near Point Piedras Blancas, California. Marine Mammal Science 15(2):598-600.

HATFIELD, B. B. 1998, 1999, and 2000. Elephant seal populations *in* Ecosystem Observations – Annual Report for the Monterey Bay National Marine Sanctuary, 299 Foam St., Monterey CA 93940

HATFIELD, B. B., D. B. MARKS, M. T. TINKER, K. NOLAN AND J. PEIRCE. 1998. Attacks on sea otters by killer whales. Marine Mammal Science 14(4):888-894.

HATFIELD, B. B. 1998. Elephant seal populations *in* Ecosystem Observations – Annual Report for the Monterey Bay National Marine Sanctuary, 299 Foam St., Monterey CA 93940

HATFIELD, B. B. 1998. Fall 1997 sea otter survey. The Otter Raft. 59:5

HATFIELD, B. B. AND G. B. RATHBUN. 1996. Evaluation of a flipper-mounted transmitter on sea otters. Wildlife Society Bulletin 24(3):551-554.

RALLS, K., B. B. HATFIELD, AND D. B. SINIFF. 1995. Foraging patterns of California sea otters as indicated by telemetry. Canadian Journal of Zoology 73:523-531

HATFIELD, B. B., R. J. JAMESON, T. G. MURPHEY, AND D. D. WOODARD. 1994. Atypical interactions between male southern sea otters and pinnipeds. Marine Mammal Science 10(1):111-114.

HATFIELD, B. B. 1992. Notes on feeding sea otters from the Washington coast. The Otter Raft. 47:10

Brian Hatfield has been involved with sea otters since the late 1970s and has been employed with USGS (migrating from USFWS) since the mid-1980s. Currently, Brian coordinates the range-wide sea otter surveys in California, including those at San Nicolas Island, and the sea otter stranding network. He is an active sea otter capture diver and has captured and handled hundreds of sea otters in most areas where sea otters occur including in the Commander and Aleutian Islands, Prince William Sound, SE Alaska, Vancouver Island, Washington, as well as California.

Brent Bancroft Hughes, Ph.D.

Assistant Professor of Community Ecology

Sonoma State University

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Website: http://hughesecology.com

Google Scholar: https://scholar.google.com/citations?user=9HfQjCEAAAAJ&hl=en&oi=ao

POSTDOCTORAL EXPERIENCE

2018 Friday Harbor Labs Postdoctoral Fellowship
University of Washington
Mentor: Dr. Megan Dethier

2015-2017 David H. Smith Conservation Research Fellow
Duke University, University of California Santa Cruz, University of Alaska
Mentors: Drs. Brian Silliman, Ginny Eckert, Kristy Kroeker, Susan Williams

EDUCATION

2010-2014 PhD Ecology and Evolutionary Biology
University of California Santa Cruz
Advisors: Drs. Kerstin Wasson and Peter Raimondi

2003 - 2007 MS Marine Science
California State University East Bay &
Moss Landing Marine Laboratories, Moss Landing, CA
Research in Phycology, Marine Community Ecology, and Oceanography
Advisor: Dr. Michael Graham

2001 Oregon Institute of Marine Biology, Charleston, OR
Graduate courses in Marine Ecology and Marine Animal Behavior

1997 - 2001 BA Biology
Truman State University, Kirksville, MO
Advisor: Dr. Lisa Hooper

PEER-REVIEWED PUBLICATIONS *Undergraduate Researcher, #Citizen Scientist

2019

Lefcheck, J.S., **B.B. Hughes**, A.J. Johnson, B. Pfirrman, D.B. Rasher, A.R. Smyth, B.L. Williams, M.W. Beck, R.J. Orth. 2019. Coastal habitats are nurseries: a comprehensive meta-analysis. *Accepted with Revisions*. **Conservation Letters**.

2018

Silliman, B.R., **B.B. Hughes**, L.C. Gaskins, Q. He, M.T. Tinker, A. Read, J. Nifong, R. Stepp. 2018. Are the ghosts of nature past haunting conservation today? ***Current Biology***. 28:R532-R537

Toft, J., S. Munsch, J. Cordell, K. Siitari, V. Hare, B. Holycross, L. DeBruyckere, C. Greene,

B.B. Hughes. 2017. Impact of multiple Stressors on estuarine nursery function across the northeast Pacific coast. ***Global Change Biology.*** 24:2008-2020.

Jeppesen, R., *M. Rodriguez, *J. Rinde, J. Haskins, **B.B. Hughes**, L. Mehner, K. Wasson. 2018. Hypoxia increases fish mortality and reduces oyster growth in a highly eutrophic estuary*.* ***Estuaries and Coasts.*** 41:89-98

<u>2017</u>

Hughes, **B.B.**, S.C. Lummis, S.C. Anderson, K.J. Kroeker. 2017. Unexpected resilience of a seagrass system exposed to global stressors*.* ***Global Change Biology****.* 24:224-234.

Hughes, B.B., R. Beas-Luna, A. Barner, K. Brewitt, D.R. Brumbaugh, E. Cerny-Chipman, S.L. Close, K.E. Coblentz, K.L. de Nesnera, S.T. Drobnitch, J.D. Figurski, B. Focht, M. Friedman, J. Freiwald, K.K. Heady, W.N. Heady, A. Hettinger, A. Johnson, K.A. Karr, B. Mahoney, M.M. Moritsch, A.K. Osterback, J. Reimer, J. Robinson, T. Rohrer, J. Rose, M. Sabal, L.M. Segui, C. Shen, J. Sullivan, R. Zuercher, P.T. Raimondi, B.A. Menge, K. Grorud-Colvert, M. Novak, M.H. Carr. 2017. Long-term studies contribute disproportionately to ecology and policy. ***BioScience*** 67:271-281.

#Eby, R., #R.S. Scoles, **B.B. Hughes**, K. Wasson. 2017. Serendipity in a salt marsh: detecting frequent sea otter haul outs in a marsh ecosystem. ***Ecology.*** 98:2975-2977.

Hessing-Lewis, M., E. Rechsteiner, **B.B. Hughes**, M.T. Tinker, A. Olson, Z. Monteith, M.M. Henderson, J.C. Watson. 2017. Ecosystem features determine seagrass community response to sea otter foraging. *In press.* ***Marine Pollution Bulletin.***

Wasson, K., R. Jeppesen, C. Endris, D. Perry, A. Woolfolk, K. Beheshti, *M. Rodriguez, #R. Eby, E. Watson, F. Rahman, J. Haskins, **B.B. Hughes**. 2017. Eutrophication decreases salt marsh resilience through proliferation of algal mats*.* ***Biological Conservation****.* 212:1-11.

Honig, S., B. Mahoney, *J. Glanz, **B.B. Hughes**. 2017. Are seagrass beds indicators of anthropogenic nutrient stress in the rocky intertidal? ***Marine Pollution Bulletin*** 114:539-546.

<u>2016</u>

Hughes, B.B., K. Hammerstrom, N. Grant, *U. Hoshijima, #R. Eby, K. Wasson. 2016. Trophic cascades on the edge: fostering seagrass resilience via a novel pathway*.* ***Oecologia*** 182:231-241.

Wasson, K., **B.B. Hughes**, A. Chang, A. Deck, P. Dinnel, S. Dudas, M. Ferner, E. Grosholz, D. Kimbro, J. Ruesink, A. Trimble, D. Vander Schaaf, C. Zabin, D. Zacherl. 2016. Coastwide recruitment of Olympia oysters: spatial scales of synchrony and predictors of recruitment failure. ***Ecology*** 97:3503-3516.

Silliman, B.R., P.M. Dixon, C. Wobus, Q. He, P. Daleo, **B.B. Hughes,** J. Willis, M. Hester. 2016. Tipping points in marsh resilience to the Deepwater Horizon oil spill. ***Nature Scientific Reports*** 6:32520. DOI: 10.1038/srep32520.

<u>2015 and earlier</u>

Hughes, B.B., M. Levey, M. Fountain, A. Carlisle, F. Chavez, M. Gleason. 2015. Climate mediates threats to fish diversity and nursery function at the land-sea interface.

Proceedings of the National Academy of Sciences USA 112:8025-8030.

Hughes, B.B., [#]R. Eby, E. Van Dyke, M.T. Tinker, C. Marks, K.S. Johnson, K. Wasson. 2013. Recovery of a top predator mediates negative eutrophic effects on seagrass. ***Proceedings of the National Academy of Sciences USA*** **110**:1513-1518.

Hughes, B.B., J. Haskins, K. Wasson, and E. Watson. 2011. Identifying factors that influence expression of eutrophication in a central California estuary. ***Marine Ecology Progress Series*** 439:31-43.

Hughes, B.B. 2010. Variable effects of a kelp foundation species on rocky intertidal diversity and species interactions in central California. ***Journal of Experimental Marine Biology and Ecology*** 393**:**90-99.

Hernandez, G.C., **B.B. Hughes** and M. Graham. 2006. Reproductive longevity of drifting kelp *Macrocystis pyrifera* (Phaeophyceae) in Monterey Bay, USA. ***Journal of Phycology*** 42:1199-1207.

PEER-REVIEWED PUBLICATIONS *IN REVIEW* OR *IN REVISION*

Hughes, B.B. (and 20 other authors). 2018. Sea otter recolonization of estuaries leads to a rediscovery of lost opportunities. *In review*.

BOOK CHAPTERS

Silliman B., **B.B. Hughes**, Y.S. Zhang, Q. He. 2017. Business as usual leads to underperformance in coastal restoration. In: *Effective Conservation Science: Data Not Dogma.* Eds. P. Kareiva, M. Marvier, B. Silliman. Ch. 27.

THESIS & DISSERTATION

Hughes, B.B. 2014. Food webs, resilience, and functioning of an estuary under multiple threats: lessons learned from Elkhorn Slough. Ph.D. Dissertation. University of California, Santa Cruz. 164 pages.

Hughes, B.B. 2007. Effects of *Egregia menziesii* on intertidal benthic assemblages. MS Thesis. California State University East Bay, Hayward. 124 pages.

TECHNICAL REPORTS

Hughes, B.B. Estuarine & Wetland Ecosystems: the first steps in developing an approach to leveraging existing monitoring programs. Report to California Ocean Science Trust, Oakland, CA USA. June, 2017.

Hughes, B.B., C. Endris, K. Beheshti, M.T. Tinker, S.L. Williams, H.G. Greene. 2016. Enhancement of healthy coastal environments by incorporating species interactions into seagrass mitigation design. California SeaGrant Report. Project # R/HCME-18PD. 23 pp.

Hughes, B.B., M.D. Levey, J.A. Brown, M.C. Fountain, A.B. Carlisle, S.Y. Litvin, C.M. Greene, W.N. Heady, M.G. Gleason. 2014. Nursery functions of U.S. west coast estuaries: the state of knowledge for juveniles of focal fish and invertebrate species. *The Nature Conservancy*, Arlington, VA. 168 pp.

Hughes, B.B., M. Fountain, A. Carlisle, M. Levey, M. Gleason. 2012. The impacts of nutrient loading and environmental conditions on the fish assemblage and available nursery habitat in Elkhorn Slough. *The Nature Conservancy*.

Hughes, B.B., J. Haskins, K. Wasson. 2010. Assessment of the effects of nutrient loading in estuarine wetlands of the Elkhorn Slough watershed: a regional eutrophication report card. *Elkhorn Slough Technical Report Series* 2010:1.

Hughes, B.B. 2009. Synthesis for management of eutrophication issues in Elkhorn Slough. *Elkhorn Slough Technical Report Series* 2009:1.

Stepehnson, M., J. Negrey, **B.B. Hughes**. 2009. Spatial and temporal trends of methyl mercury in California bays and harbors: A bioaccumulation approach to assess fish and water quality. *California State Water Resources Control Board Technical Report.*

Stephenson, M., W. Heim**, B.B. Hughes**, A. Bonnema and K. Coale. 2008. Methylmercury loading studies in Delta wetlands. *CALFED Mercury Project*, Task 5.3a.

POPSCI ARTICLES

Hughes, B.B. 2017. Searching for the southern sea otter. Lost and Found Blog. http://www.lostandfoundnature.com/blog/2017/08/18/searching-for-the-southern-sea-otter/

Hughes, B.B. River otters in a land without rivers. 2018. San Juan Islander. https://sanjuanislander.com/opinion/columnists/tide-bites/27960/river-otters-in-a-land-without-rivers

*Ali, B., *N. Noor, *S. Soto, **B.B. Hughes.** River otters lurking in the sea: further evidence of a paradigm shift in conservation. 2018. Society for Conservation Biology News Blog. https://conbio.org/publications/scb-news-blog/river-otters-lurking-in-the-sea-further-evidence-of-a-paradigm-shift-in-con

PRESS

For links to selected media coverage of my research go to: http://hughesecology.com/in-the-news/

Hughes et al. (2017) BioScience: Highlighted on the BioScience cover, Oregon State University, UC Santa Cruz

Hughes et al. (2015) PNAS: Highlighted on the PNAS cover, Highlighted in commentary by Nancy Rabalais PNAS, Newsweek, Science Daily, American Fisheries Society, UC Santa Cruz, Santa Cruz Sentinel, PNAS Blog, Monterey County Herald

Hughes et al. (2013) PNAS and associated sea otter research: National Geographic, BBC, NPR, Al Jazeera, LA Times, Science Daily, Huffington Post, Christian Science Monitor, The Australian, The Guardian, Mongabay, BioScience, The China Post, UC Santa Cruz, Santa Cruz Sentinel, PNAS Blog, French Tribune, Science Recorder, The Inquisitir, Monterey County

Herald, Nature Conservancy Magazine, Southern California Public Radio, Canadian Broadcasting Company Radio, Lost and Found Blog

Hughes et al. (2011) MEPS: Santa Cruz Sentinel, UC Santa Cruz

GRANTS & PI EXPERIENCE

California Coastal Conservancy. Determining habitat extent and population growth of sea otter recolonization of northern California. $[redacted] 2019-2020. PI: **BB Hughes**.

Koret Scholars Award. Scale-dependency in coastal food webs along the California Current. $[redacted] PI: **BB Hughes** (Awarded with 4 undergraduates at SSU).

Anthropocene Institute. Enhancing restoration design of imperiled Olympia oysters in a highly degraded estuary [redacted] 2017-2018. PIs: **BB Hughes**, K. Wasson.

NSF BIO-OCE. Trophic linkages in seagrass ecosystems. [redacted] 2016-2019. PI: G Eckert, Senior Personnel: T. Tinker, **BB Hughes.**

California Ocean Science Trust. Estuarine & Wetland Ecosystems Monitoring Program Integration. [redacted] 2016-2017. PI: **BB Hughes.**

The Ocean Foundation. Ecosystem functioning of restored seagrass beds. [redacted] 2016-2017. PI: **BB Hughes.**

Anthropocene Institute/Ocean Foundation, "Restoration of eelgrass to and its effects to key ecosystem services and water quality". [redacted], 2016-2017. PI: **BB Hughes**.

California Sea Grant, "Enhancement of healthy coastal environments by incorporating species interactions into seagrass mitigation and restoration design", [redacted] 2015-2016. PI: HG Greene. **BB Hughes, Ghost author and project leader**.

The Nature Conservancy Grant "Nursery Functions of West Coast Estuaries: A State of the Knowledge Report", [redacted] 2013-2014. PIs: **BB Hughes**, J Brown, M Levey, A Carlisle, S Litvin, M Fountain

Central Coast Regional Water Quality Control Board Grant "Discharge measurements for the Tembaldero Slough: determining nutrient loading to Elkhorn Slough", [redacted] 2014. PIs: J Haskins, **BB Hughes**

The Nature Conservancy Grant "Investigation of the relationship between the nursery function of estuaries and nutrient loading", [redacted] PIs: **BB Hughes,** M Fountain, M Levey, A Carlisle

NOAA Recovery and Reinvestment Act via the Elkhorn Slough Tidal Wetland Program for eutrophication research and monitoring[redacted]-11.

Earl and Ethel Meyers Foundation Grant for research [redacted] 2011

David and Lucile Packard Foundation Grant for research [redacted], 2005

PADI Foundation Grant for research[redacted], 2005

Earl and Ethel Meyers Foundation Grant for research [redacted], 2005

FELLOWSHIPS & AWARDS

University of Washington, Friday Harbor Labs Postdoctoral Fellowship ~[redacted] 2018-2019

David H. Smith Postdoctoral Conservation Fellowship [redacted], 2015-2017

NOAA - Walter B. Jones Memorial Award for Excellence in Coastal and Marine Graduate Study, 2014

NOAA National Estuarine Research Reserve Graduate Research Fellowship [redacted], 2011-2014

Rebecca and Steve Sooy Fellowship in Marine Mammals [redacted], 2014

UCSC Department of Ecology and Evolutionary Biology Research Award [redacted] 2014

UCSC Department of Ecology and Evolutionary Biology Research Award [redacted] 2013

UCSC Department of Ecology and Evolutionary Biology Research Award[redacted], 2012

Friends of Long Marine Laboratory Student Research Award [redacted] 2012

UCSC Department of Ecology and Evolutionary Biology Research Award $1700, 2011

UCSC STARS Re-entry Student Scholarship $[redacted] 2011

Friends of Long Marine Laboratory Student Research Award [redacted] 2011

Coastal and Estuarine Research Federation Student Travel Award [redacted] 2011

California Estuarine Research Society Student Travel Award [redacted], 2011

2nd place Student Poster Award, Northwest Algal Symposium 2005

Americorps Academic Scholarship [redacted], August 2001

RESEARCH EXPERIENCE

2008 - 2014 *Estuarine Ecologist*, Elkhorn Slough National Estuarine Research Reserve, Watsonville, CA.

2008 - 2013 *Research Diver*, Sandoval and Associates, Salinas, CA.

2005 - 2008 *Research Analyst*, Moss Landing Marine Labs, Moss Landing, CA.

2006 - 2008 *Consultant*, Carlsbad Aquafarm, Carlsbad, CA.

2002 - 2007 *Research Assistant*, Moss Landing Marine Labs, Moss Landing, CA

2000 - 2001 *Independent Research*, Truman State University, Kirksville, MO
"Light induced inhibition of *Myxococcus xanthus* development"

1999 - 2000 *Research Assistant*, Truman State University, Kirksville, MO

TEACHING EXPERIENCE (Instructor or co-instructor)

2018-present *Faculty*, Sonoma State University, courses taught: Ecology, Marine Ecology, Intro to R
2016 *Course Co-Instructor*, Duke University, Marine Ecology field course
2015 *Course Co-Instructor*, University of California Santa Cruz, Marine Conservation Biology class
2008 - 2010 *Adjunct Faculty*, Cabrillo College, courses taught: Ecology
2005 *Instructor*, MLML Teacher Enhancement Program, taught high school marine botany in Watsonville, CA.

Invited Lectures and TAships

2017 *Invited Lecturer*, Stanford University, Exploring the Critical Interface Between the Land and Monterey Bay: Elkhorn Slough
2016 *Invited Lecturer*, Duke University, Marine Ecology class
2016 *Invited Lecturer*, University of California Santa Cruz, Marine Ecology class
2015 *Invited Lecturer*, Duke University, Marine Mammals class
2015 *Invited Lecturer,* University of California Santa Cruz, Marine Botany class
2014 *Invited Lecturer,* University of California Santa Cruz, Ecology class
2014 *Invited Lecturer,* University of California Santa Cruz, Marine Ecology class
2014 *Invited Lecturer,* University of California Santa Cruz, Marine Botany class
2013 *Invited Lecturer,* University of California Santa Cruz, Marine Botany class
2012 *Invited Lecturer*, Stanford University, Human Ecology class
2012 *Invited Lecturer*, Moss Landing Marine Labs, Chemical Oceanography class
2012 *Invited Lecturer*, University of California Santa Cruz, Marine Botany class
2012 *Invited Instructor*, Elkhorn Slough National Estuarine Research Reserve's Coastal Training Program. Workshop on water quality issues in Monterey Bay, CA
2012 *Invited Instructor* for the Monterey Area Research Institutions' Network for Education (MARINE) workshop on water quality issues in Elkhorn Slough, CA
2011 *Invited Lecturer*, University of California Santa Cruz Marine Botany class
2010 - 2014 *Teaching Assistant,* University of California Santa Cruz, Courses: Cell and Molecular Biology, Life in the Sea, Marine Botany (3x), Plant Physiology, Ecology and Evolution
2010 *Invited Lecturer*, Cabrillo College Ecology class
2009 -present *Research Mentor* for 21 students from California State University Monterey Bay's Undergraduate Research Opportunities Center (UROC), Hartnell College, the University of California Santa Cruz, Duke University and Stanford University
2002 - 2005 *Teaching Assistant*, Moss Landing Marine Labs, Courses: Kelp Ecology and Marine Ecology, assisted in designing lectures for Marine Botany

Mentored Students (G = Graduate, U = Undergraduate)

University of California Santa Cruz – Kathryn Beheshti (G), Sean Abby (U), Jessica Glanz, (U), Umi Hoshijima (U), Brett Bulkin (U), Leo Hijikata (U), Scott Borsom (U), Erica Ferrer (U), Tanya Guzman, (U), Luis Hernandez (U), Caitlin Seyfried (U), Nicole D'Antonio (G), Adri Sparks (U), Anthea Fredrickson (U), Daniel Inglese (U), Stephanie Douglas (U)
CSU Monterey Bay – Miguel Rodriguez (U), Jared Worland (U), Lizz Johnson (U), Jenna Van Parys (U)
Stanford University – Ju Lee (G)
University of Arizona - Abby Gritis (U, 2017 Doris Duke Scholar)
St. Olaf – Bashir Ali (U, 2018 Doris Duke Scholar)
UC Berkeley – Soledad Soto (U, 2018 Doris Duke Scholar)
University of Florida – Nusrat Noor (U, 2018 Doris Duke Scholar)

Duke University – Lindsay Gaskins (G, committee member)
San Diego State University – Tracy Grimes (G)
University of Alaska Fairbanks – Wendel Raymond (G)
San Francisco State University Jane Rudebusch (G, committee member)
Sonoma State: Aanisah Houston (U), Lauren Bocca (U), Jessica Saavedra (U), Natasha Higuera (U)

INVITED SEMINARS and TALKS

Hughes, B.B. Sep 2018. Sea otters and estuaries: paradise lost. *Invited public seminar*. Sea Otter Awareness Week. Morro Bay, CA.

Hughes, B.B., D. Gossard, P. Hain, M.H. Graham, K. Wasson. Aug 2018. Aquaculture as a tool for restoring native oysters and understanding lost species interactions. *Invited talk*. Pathways Toward Responsible Aquaculture in California Workshop. Moss Landing Marine Labs, Moss Landing, CA.

Hughes, B.B., S. Lummis, K. Kroeker, S. Anderson. June 2018. Resilience of a seagrass system exposed to ocean acidification and nutrient enrichment. *Invited talk*. ASLO 2018 Summer Meeting.

Hughes, B.B. March 2018. Food webs, resilience, and functioning of coastal ecosystems. *Invited Seminar*. University of Washington, Friday Harbor Labs.

Hughes, B.B. March 2018. Food webs, resilience, and functioning of coastal ecosystems. *Invited Seminar*. Florida State University Coastal and Marine Laboratory.

Hughes, B.B. March 2018. Food webs, resilience, and functioning of coastal ecosystems. *Invited Seminar*. University of Chicago, Marine Biology Laboratory.

Hughes, B.B. March 2018. Food webs, resilience, and functioning of coastal ecosystems. *Invited Seminar*. University of Alaska Fairbanks.

Hughes, B.B. February 2018. Food webs, resilience, and functioning of coastal ecosystems. *Invited Seminar*. Sonoma State University, Biology Department.

Hughes, B.B. February 2018. Food webs, resilience, and functioning of coastal ecosystems. *Invited Seminar*. California State University East Bay, Biology Department.

Hughes, B.B. May 2017. Food webs, resilience, and functioning of coastal ecosystems. *Invited Webinar*. Canadian Society of Environmental Biologists.

Hughes, B.B. April 2016. Food webs, resilience, and functioning of coastal ecosystems under threat from multiple anthropogenic stressors. *Invited Seminar*. University of California Santa Cruz, Ocean Science Department.

Hughes, B.B. March 2016. Food webs, resilience, and functioning of coastal ecosystems. *Invited Seminar*. University of Florida.

Hughes, B.B., M. Fountain, A. Carlisle, M. Gleason, M. Levey. February 2016. Climate mediates threats to fish diversity and nursery function at the land-sea interface. *Invited Talk*

Ocean Sciences Meeting.

Hughes, B.B., M. Fountain, A. Carlisle, M. Gleason, M. Levey. November 2015. Climate mediates threats to fish diversity and nursery function at the land-sea interface. *Invited Talk* Coastal and Estuarine Research Federation Biennial Conference.

Hughes, B.B. October 2015. Food webs, stability, and functioning of nearshore and estuarine ecosystems in the northeast Pacific. *Invited Seminar*. Monterey Bay Aquarium Research Institute.

Hughes, B.B. September 2015. Can sea otters defend and restore our coastlines? *Invited Seminar*. Duke Marine Lab.

Hughes, B.B. April 2015. Food webs, stability, and functioning of nearshore and estuarine ecosystems in the northeast Pacific. *Invited Seminar*. University of Washington, School of Aquatic and Fishery Sciences.

Hughes, B.B. March 2015. Food webs, resilience, and functioning of an estuary under multiple threats: lessons learned from Elkhorn Slough. *Invited Seminar.* Moss Landing Marine Laboratories.

Hughes, B. T. Tinker. November 2014. Oral Presentation. From kelp forests to pickle weed: sea otter effects on ecosystem dynamics in two distinct coastal habitats. Presented to the staff for Monterey Bay Aquarium's Conservation Science Seminar Series.

Haskins, J., **B. Hughes**, K. Wasson. March 2014. Oral Presentation. *Invited Public Seminar*. Long-term water quality monitoring and eutrophication research at Elkhorn Slough. Presented to the Central Coast Regional Water Quality Control Board. Salinas, CA.

Hughes, B. The surprising case of the reappearing seagrass. November 2013. Oral Presentation. *Invited Public Seminar.* Elkhorn Slough Foundation.

Hughes, B. Can sea otters mediate the harmful effects of nutrient pollution on seagrass? September 2012. Oral Presentation. *Invited Public Seminar*. Sea Otter Awareness Week, California State University, Monterey Bay.

Hughes, B. Linking watershed activities to nearshore ecosystem processes: a case study of Elkhorn Slough. February 2012. *Invited Seminar*. California State University Monterey Bay, Division of Science and Environmental Policy.

CONTRIBUTED PAPERS

Hughes, B., K. Beheshti, L. Carswell, B. Silliman, M. Tinker, S. Williams. Are sea otters the solution for coastal restoration in the North Pacific? July 2017. Oral Presentation. International Congress for Conservation Biology; Cartagena, Colombia.

Hughes, B., K. Beheshti, C. Angelini, T. Tinker, K. Wasson, B. Silliman. Top predator recovery suppresses die-back of shoreline-protecting salt marshes through a trophic cascade. January 2017. Oral Presentation Elkhorn Slough Research Symposium.

Hughes, B., K. Beheshti, C. Angelini, T. Tinker, B. Silliman. Top predator recovery suppresses die-back of shoreline-protecting salt marshes through a trophic cascade. November 2016. Oral presentation. Western Society of Naturalists.

Hughes, B., K. Beheshti, C. Angelini, T. Tinker, K. Wasson, B. Silliman. Sea otter expansion in estuaries can trigger system-wide recovery. March 2016. Oral Presentation. Southern Sea Otter Research Alliance Meeting. University of California, Santa Cruz.

Hughes, B. The return of sea otters to estuaries, implications for ecosystem resilience, functioning, and conservation. February 2014. Oral Presentation. Southern Sea Otter Research Alliance Meeting. University of California, Santa Cruz.

Levey, M.D., **B. Hughes**. Mapping the implications of low oxygen (hypoxia) on available habitat for select species of flatfish in Elkhorn Slough. November 2013. Oral Presentation. ESRI Ocean GIS Forum. Redlands, California, USA.

Hughes, B. Why is the estuary green and why should we care? January 2013. PhD Proposal Seminar. University of California, Santa Cruz.

Hughes, B., R. Eby, E. Van Dyke, K. Wasson. 2012. Sea otters mediate negative eutrophication effects on seagrass through a multi-level trophic cascade. November 2012. Oral Presentation. Western Society of Naturalists.

Hughes, B., M. Fountain, A. Carlisle, M. Levey, and M. Gleason. Synergistic effects of eutrophication and large-scale climatic patterns on an estuarine fish assemblage. September 2012. Oral Presentation. California Estuarine Research Society Meeting.

Hughes, B. The role of scale when determining the relative importance of bottom-up forces and species interactions on seagrass populations. December 2011. Oral Presentation. Species Interaction Workshop, Stanford University.

Hughes, B., J. Haskins, K. Wasson, E. Watson. 2011. Identifying factors that influence expression of eutrophication in a central California estuary. November 2011 Oral presentation. Coastal and Estuarine Research Federation Biennial Conference.

Hughes, B., J. Haskins, K. Wasson. Eutrophication assessment of Elkhorn Slough, CA. February 2010. Poster Presentation. National Estuarine Research Reserve Annual Technical Meeting.

Hughes, B., K. Wasson, and J. Haskins. Patterns and filters of eutrophication endpoints in Elkhorn Slough. January 2010. Oral presentation. Elkhorn Slough Research Symposium.

Hughes, B., K. Wasson, J. Haskins. Spatial variability in eutrophication indicators across a tidal gradient in Elkhorn Slough, CA. November 2009. Oral presentation. Coastal and Estuarine Research Federation Biennial Conference.

Hughes, B. Effects of *Egregia menziesii* on intertidal benthic assemblages. April 2007. Thesis Defense. Moss Landing Marine Laboratories

Hughes, B. Effects of *Egregia menziesii* populations on rocky intertidal algal assemblages. November 2005. Oral presentation. Western Society of Naturalists Annual Meeting.

Hughes, B. Effects of *Egregia menziesii* populations on rocky intertidal algal assemblages. April 2005. Poster Presentation. Northwest Algal Symposium.

Kupfer, R., **B. Hughes**. Effects of light exposure on *Myxococcus xanthus* development. April 2002. Poster Presentation. Missouri Academy of Sciences Annual Meeting.

Hughes, B. Light induced inhibition of *Myxococcus xanthus* development. April 2002. Poster Presentation. Truman State University Undergraduate Research Symposium.

Hughes, B. Light induced inhibition of *Myxococcus xanthus* development. April 2001. Oral presentation. Truman State University Tri Beta meeting.

PUBLIC OUTREACH AND SYNERGISTIC ACTIVITIES

Hughes, B. Space invader's view of seagrass restoration: a success story from California. October 2018. Invited Presentation. SF Bay Ocean Conservation Meeting.

Hughes, B. New paradigms for coastal conservation in the 21st Century. September 2017. Invited Presentation. Friends and Anemones Society.

Hughes, B.B. Food webs, resilience, and functioning of coastal ecosystems. *Invited Seminar*. March 2018. Lions Club, Friday Harbor, WA.

Hughes, B.B. River Otters in a Land Without Rivers. May 2018. *Invited seminar*. University of Washington Friday Harbor Labs Open House.

Hughes, B. Top predator recovery presents new conservation challenges in the 21st century. September 2016. *Invited Presentation*. Monterey Bay Aquarium Volunteer Enrichment Series.

Hughes, B. Los efectos de fertilizantes a la ecología de Elkhorn Slough. March 2012. Presentación Oral en Español. Monterey Bay AgExpo.

Hughes, B., K. Wasson, J. Haskins. Spatial variability in eutrophication indicators across a tidal gradient in Elkhorn Slough, CA. December 2009. Oral Presentation. Monterey Bay National Marine Sanctuary/Water Quality Protection Program Quarterly Meeting.

Wasson, K., E. Van Dyke, J. Haskins, **B. Hughes**. Parsons Sill Project predictions for habitats, water quality, and biological communities. September 2009. Oral Presentation. Elkhorn Slough Tidal Wetland Project: Science Panel and Strategic Planning Team Meeting.

Hughes, B. Attack of the killer kelp. April 2006. Oral presentation. Moss Landing Marine Laboratories Open House. *Public Outreach Seminar.*

MENTORED GRADUATE# & UNDERGRADUATE* STUDENT PRESENTATIONS

#Lee, J., F. Micheli, **B.B. Hughes**, K.J. Kroeker. Are mutualistic interactions between seagrass and epiphyte grazer resilient to future ocean acidification? Western Society or Naturalists. Pasadena, CA. November 2017. Oral Presentation.

#Espinosa, S.M., Endris, C., Staedler, M.S., Fujii, J.A., **Hughes, B.B.**, Beheshti, K, Eby, R.G., Scoles, R.W., Bentall, G.B., Wasson, K., Tinker, M.T. Predictors of sea otter habitat use of salt marsh in Elkhorn Slough, CA. Western Society or Naturalists. Pasadena, CA. November 2017. Oral Presentation.

#Grimes, T.G., M.T. Tinker, **B.B. Hughes**, R.L. Lewison. Patterns of sea otter foraging activity and juvenile Dungeness crab habitat use. Western Society or Naturalists. Pasadena, CA. November 19, 2017. Poster Presentation.

#Lee, J., F. Micheli, **B.B. Hughes**, K.J. Kroeker, K.G. Peay. Effects of Ocean Acidification on surfgrass interaction with epiphytes, grazers, and opportunistic microbes. Western Society for Naturalists. Monterey, CA. November 12, 2016.

#Beheshti, K.M., **Hughes, B.B.**, Boyer, K, Greene, H.G., Endris, C. “Seagrass Restoration and the Trajectory of Enhanced Ecosystem Functioning.” Western Society for Naturalists. Monterey, CA. November 12, 2016. 15-Minute Talk.

#Beheshti, K., **Hughes, B.**, Silliman, B., Angelini, C. “Crab Facilitation of Salt Marsh Loss: Abiotic Stressors Made Worse by Ecosystem Engineers.” Western Society for Naturalists. Sacramento, CA. November 7, 2015.

#Beheshti, K., **Hughes, B.** et al. “How *Pachygrapsus crassipes* affect *Sarcocornia pacifica* loss in Elkhorn Slough, CA.” 6th Annual Ecology and Evolutionary Biology Symposium. Long Marine Laboratory, Santa Cruz. May 8, 2015. 5-Minute Ignite Talk.

#Beheshti, K., **Hughes, B.** et al. “From *Sarcocornia* to *Zostera*: Just add water.” 7th Annual Ecology and Evolutionary Biology Symposium. Long Marine Laboratory, Santa Cruz. April 29, 2016. 15-minute talk.

*Glanz, J., *B. Bulkin, **B. Hughes**. Trophic diversity influences growth strategies and competitive interactions in the eelgrass *Zostera marina*. Poster Presentation. Western Society of Naturalists November 2012, UC Santa Cruz Plant Research Symposium Feb 2013, Monterey Bay National Marine Sanctuary Currents Symposium April 2013.

*Abbey, S and **B. Hughes.** Impacts of anthropogenic nutrient loading on competitive interactions between eelgrass and ephemeral algae. April 2012. Poster Presentation. Monterey Bay National Marine Sanctuary Currents Symposium

*Van Parys, J., *M. Rodriguez, R. Preisler, J. Haskins, **B. Hughes**, and K. Wasson. October 2011. Water Quality at Elkhorn Slough and its impacts on Olympia Oysters (*Ostrea lurida*) and Staghorn Sculpins (*Leptocottus Armatus*). Poster Presentation SACNAS Annual Conference.

*Rodriguez, M., J. Haskins, **B. Hughes**, R. Preisler, K. Wasson. The relationship between water depth and hypoxia in managed estuarine wetlands: analysis and management recommendations. April 2011. Poster Presentation. Monterey Bay National Marine Sanctuary Currents Symposium.

*Johnson, L., **B. Hughes**. Variable effects of *Ulva* spp. on dissolved oxygen dynamics. April 2010. Poster Presentation. Monterey Bay National Marine Sanctuary Currents Symposium.

PROFESSIONAL SERVICE

Society for Conservation Biologists (Honorary Lifetime Membership)
Pacific Marine and Estuarine Fish Habitat Partnership (PMEP), Spatial Data Work Group (2015-present)
Session Co-Chair (Kerry Nichols, Tessa Hill, Kristy Kroeker), Coastal and Estuarine Research Federation, November 2015. "Multiple stressors in vegetated coastal ecosystems."
California Estuarine Research Society Student Representative (2011-2013)
Phycological Society of America (2003-2006), (2011-2015)
Elkhorn Slough Research Symposium, 2010 conference coordinator
Elkhorn Slough Tidal Wetland Program, Science Panel (2009-present)
California Estuarine Research Society (2009-present)
Coastal and Estuarine Research Federation (2009-present)
Northwest Algal Society (2005-2010)
Western Society of Naturalists (2004-present)
Monterey Bay National Marine Sanctuary, Water Quality Protection Program Committee (2009-2013)
Student Body Vice President, Moss Landing Marine Labs (2002-03).

MANUSCRIPT REVIEWER (SINCE 2011)

Nature Climate Change (1x), *Nature Communications* (1x), *Trends in Ecology and Evolution* (1x), *Conservation Letters* (1x), *Global Change Biology* (1x), *Frontiers in Ecology and the Environment* (1x) *BioScience* (1x), *Ecology* (3x), *Oecologia* (1x), *Journal of Ecology* (1x), *Ecosphere* (1x), *Estuaries and Coasts* (1x), *Marine Ecology Progress Series* (3x), *Journal of Experimental Marine Biology and Ecology* (1x), *Estuarine Coastal and Shelf Science* (1x), *Journal of Sea Research* (1x), *Environmental Biology of Fishes* (1x), *Marine Biology Research* (1x), *Elkhorn Slough Technical Report Series* (2x), *Pacific Marine and Estuarine Fish Habitat Partnership* (1x)

PROPOSAL REVIEWER (SINCE 2015)

NSF Biological Oceanography (1x), National Geographic Society (1x), Washington SeaGrant Panelist (1x), The Fram Centre (Norway) (2x), Earthwatch (1x), North Pacific Research Board (1x)

SKILLS

Field Skills: California boater certified, AAUS and NAUI Master and Scientific diver certified (200+ dives), CPR and First Aid certified, marine algal/invertebrate/vertebrate identification, ecological sampling techniques, acoustic tracking, ADCP, YSI, CTD, Water Quality.

Laboratory Skills: Sterile technique, Microscopy, Fluorometry, Spectrophotometry, Stable Isotopes, Cell culture, image analysis, media preparation.

Computer and Programming Skills: R, Systat, SPSS, SPSS Amos, JMP, Primer, ArcGIS, Canvas, Image J, Endnote, RiverSurveyor, View Argonaut, Microsoft Access/Word/Excel/Power Point, Adobe Photoshop, and website design and maintenance.

COMMUNITY & VOLUNTEER SERVICE

River Otter Day at Tomales High School. November 2019. *Invited Panelist*.
Friday Harbor Elementary School Volunteer Science Teacher, 2018.
Santa Cruz City School District, Volunteer Science and Music Teacher 2015-17
Monterey Bay Aquarium algal taxonomist, 2006-07
High School Teacher Enhancement Program, Moss Landing, CA 2005-06
Americorps volunteer, Kansas City, KS 2000
Special Olympics basketball league coordinator, Olathe, KS 1996-97
American Heart Association volunteer, Kansas City, MO 1994-97

KEY COLLABORATORS

Brian Silliman, Associate Professor, Duke University
Susan Williams, Professor, University of California Davis
M. Tim Tinker, Research Wildlife Biologist & Adjunct Professor, USGS and UC Santa Cruz
Kristy Kroeker, Assistant Professor, UC Santa Cruz
Ken Johnson, Senior Scientist, Monterey Bay Aquarium Research Institute
Kerstin Wasson, Research Coordinator, Elkhorn Slough National Estuarine Research Reserve
Christine Angelini, Assistant Professor, University of Florida
Mary Gleason, Associate Director of Marine Science, The Nature Conservancy
Mike Beck, Lead Marine Scientist, The Nature Conservancy
Aaron Carlisle, Post-doctoral Researcher, Stanford University
Margot Hessing-Lewis, Research Faculty, Hakai Institute
Ginny Eckert, University of Alaska Fairbanks
Lisa Needles, California Polytechnic University

PROFESSIONAL REFERENCES

[redacted]

[redacted]

Curriculum Vitae

Aug 2018

David R Casper DVM
University of California, Santa Cruz
Long Marine Laboratory
100 Shaffer Rd., Santa Cruz, CA 95060
Office 831.459.3135 Fax 831.459.3383
Email: dcasper@ucsc.edu

Education

Medical DVM, University of Illinois, Champaign Urbana, IL 1973, Phi Zeta Honor Society
Bachelor of Veterinary Medicine, University of Illinois, Champaign Urbana, IL 1971, Edmund J. James Scholar

Current Position

Director of Veterinary Services at UCSC
Director of BioMed Vivarium at UCSC
Director LML Marine Mammal Stranding network
Attending Veterinarian, Long Marine Laboratory
Attending Veterinarian Moss Landing Marine Lab
Contract Veterinarian Monterey Bay Aquarium

Professional Affiliations

International Association of Aquatic Animal Medicine
Society for Marine Mammalogy
American Association of Zoos and Aquaria
American Veterinary Medical Association
California Veterinary Medical Association

Professional Experience

2000-present	Sea Otter surgical implantation of transmitters, central California coast
2000-present	Contract Veterinarian Monterey Bay Aquarium
1997-present	Director LML Marine Mammal Stranding network
2000-2003	“Tagging of Pacific Pelagics” project (TOPP), sampling and tagging free-ranging sea lions
1995-99	White shark tagging and tracking program, Año Nuevo Island, CA
1996-99	Leopard shark ecology, Elkhorn Slough Research Reserve, Elkhorn, CA
1993	NMFS Dolphin live capture, Beaufort, NC
1992	White sided dolphin research project, UCSC
1992	NMFS Dolphin live capture, Matagorda Bay, TX
1989-91	Director of Research and Veterinary Services, John G. Shedd Aquarium, Chicago, Ill
1989	Dolphin Biology Research Associates live capture, Sarasota, FL
1989	White sided dolphin research project, UCSC
1988	Dolphin Biology Research Associates live capture, Sarasota, FL

Research and Publications

Coccidioidomycosis and Other Systemic Mycoses of Marine Mammals Stranding Along The Central California, USA Coast: 1998-2012
By: Huckabone, Sara E.; Gulland, Frances M. D.; Johnson, Suzanne M.; et al.
JOURNAL OF WILDLIFE DISEASES Volume: 51 Issue: 2 Pages: 295-308 Published: APR 2015

Recovery rates of bottlenose dolphin (Tursiops truncatus) carcasses estimated from stranding and survival rate data
JAMES V. CARRETTA,1 KERRI DANIL, SUSAN J. CHIVERS et al.
Marine Mammal Science
Volume 32, Issue 1, Article first published online: 4 SEP 2015Biochemical and hormonal changes during acute fasting and re-feeding in bottlenose dolphins (Tursiops truncatus)
By: Ortiz, Rudy M.; Long, Brett; Casper, Dave; et al.
MARINE MAMMAL SCIENCE Volume: 26 Issue: 2 Pages: 409-419 Published: APR 2010

An Unusual Mortality Event of Harbor Porpoises (Phocoena phocoena) Off Central California: Increase in Blunt Trauma Rather Than an Epizootic
By: Wilkin, Sarah M.; Cordaro, Joe; Gulland, Frances M. D.; et al.
AQUATIC MAMMALS Volume: 38 Issue: 3 Pages: 301-310 Published: 2012

Isotopic incorporation rates for shark tissues from a long-term captive feeding study
By: Kim, Sora Lee; del Rio, Carlos Martinez; Casper, Dave; et al.
JOURNAL OF EXPERIMENTAL BIOLOGY Volume: 215 Issue: 14 Pages: 2495-2500 Published: JUL 2012

Carbon and nitrogen discrimination factors for elasmobranch soft tissues based on a long-term controlled feeding study
By: Kim, Sora Lee; Casper, Dave R.; Galvan-Magana, Felipe; et al.
ENVIRONMENTAL BIOLOGY OF FISHES Volume: 95 Issue: 1 Special Issue: SI Pages: 37-52 Published: SEP 2012

Meningoencephalitis Associated With Carnobacterium maltaromaticum-Like Bacteria in Stranded Juvenile Salmon Sharks (Lamna ditropis)
Schaffer, P. A.; Lifland, B.; Van Sommeran, S.; et al.
VETERINARY PATHOLOGY Volume: 50 Issue: 3 Pages: 412-417 Published: MAY 2013

Biochemical and hormonal changes during acute fasting and re-feeding in bottlenose dolphins (Tursiops truncatus)
By: Ortiz, Rudy M.; Long, Brett; Casper, Dave; et al.
MARINE MAMMAL SCIENCE Volume: 26 Issue: 2 Pages: 409-419 Published: APR 2010

Running, swimming and diving modifies neuroprotecting globins in the mammalian brain
Williams, TM (Williams, Terrie M.)[1] ; Zavanelli, M (Zavanelli, Mary)[2] ; Miller, MA (Miller, Melissa A.)[5,4] ; Goldbeck, RA (Goldbeck, Robert A.)[3] ; Morledge, M (Morledge, Michael)[2] ; Casper, D (Casper, Dave)[1] ; Pabst, DA (Pabst, D. Ann)[6] ; McLellan, W (McLellan, William)[6] ; Cantin, LP (Cantin, Lucas P.)[3] ; Kliger, DS (Kliger, David S.)[3]
PROCEEDINGS OF THE ROYAL SOCIETY B-BIOLOGICAL SCIENCES
Volume: 275 Issue: 1636 Pages: 751-758
Published: APR 7 2008

Seasonal Variability in Otariid Energetics: Implications for the effects of predators on localized prey resources, Terrie M. Williams, M. Rutishauser, B. Long, T. Fink, J. Gafney, H. Mostman-Liwanag, D. Casper , Physiological and Biochemical Zoology, May:80(4)

Absence of neurotoxic effects in leopard sharks, Triakis semifasciata, following domoic acid exposure. Schaffer P, Reeves C, Casper DR, Davis CR. Toxicon. 2006 Jun 1;47(7):747-52. Epub 2006 Mar 29
Incidence of Temporomandibular Arthritis in California Sea Lions (*Zalophus californianus*).
David Aurioles-Gamboa, Claudia Diaz-Guzman, Burney J. Le Bœuf, David Casper (in preparation)

Characterization and Clinical Manifestations of Arcanobacterium Phocae Infections in Marine Mammals Stranded Along the Central California Coast

Shawn Johnson, Spencer Jang, Frances Gulland, Melissa Miller, Dave Casper, Judy Lawrence, Juliet Herrera
J Wildl Dis. 2003 Jan;39(1):136-44.

CANINE DISTEMPER VACCINATION IS A SAFE AND USEFUL PREVENTIVE PROCEDURE FOR SOUTHERN SEA OTTERS (ENHYDRA LUTRA NEREIS)
By: Jessup, David A.; Murray, Michael J.; Casper, David R.; et al.
JOURNAL OF ZOO AND WILDLIFE MEDICINE Volume: 40 Issue: 4 Pages: 705-710 Published: DEC 2009

Bottlenose Dolphins as Marine Ecosystem Sentinels: Developing a Health Monitoring System
Randall S. Wells, Howard L. Rhinehart, Larry J. Hansen, Jay C. Sweeney, Forrest I. Townsend, Rae Stone, David Casper, Michael D. Scott, Aleta A. Hohn, and Teri K. Rowles
EcoHealth 1, 246–254, 2004 Special issue of "Ecosystem Health" dedicated to symposium in October 2000 in New York

In Vitro Lymphocyte Responses Of Bottlenose Dolphins (Tursiops Truncatus): Mitogen Induced Proliferation
Garet P. Lahvis, Randall S. Wells, David Casper , and Charles S. Via
Marine Environmental Research 34 (1992) 000-000, Elservier Science Publishing, London, Eng.

Bottlenose Health Assessment: Field Report On Sampling Near Beaufort, North Carolina, During July, 1995
NOAA Technical Memorandum NMFS-SEFSC-382

First Record of A Live-Stranded Pan-Tropical Spotted Dolphin Stenella-Attenuata-graffmani in Central California USA.
Worthy, G; Casper, D; Rhinehart, H; Moser, M.
Marine Mammal Science, v.9, n.3, (1993): 316-319.

WEBSITES

http://www.mmapl.ucsc.edu/
Marine Mammal Pathology Library
The Marine Mammal Anatomy and Pathology Library (MMAPL) is a resource for high quality images, information, and training tools describing normal anatomy and species specific pathologies of marine mammals.
MMAPL was developed for the marine mammal stranding community, the larger marine mammal research community, veterinarians, pathologists, and educators.
17 intuitional partners contributed to this project.
Collaboration was key to the development of this unique resource and continues to be critical as MMAPL continues to grow and evolve.

REPORTS

Blood Profiles Of Free-Ranging Bottlenose Dolphins From The Central West Coast Of Florida: Report submitted to the Southeast Fisheries Center of the National Marine Fisheries Service
H. Rhinehart, R. S. Wells, F.. Townsend, J. C. Sweeney, D. R. Casper

Health Assessment Of A Population Of Bottlenose Dolphins, Tursiops Truncatus, At Matagorda Bay, Texas, Following A Mortality Event: Report submitted to the Southeast Fisheries Center of the National Marine Fisheries Service
J. C. Sweeney, D. R. Casper F.. Townsend, L. R Stone, and Larry Hansen

A Model for Assessing the Relative Health of Dolphin Populations: Report submitted to the Southeast Fisheries Center of the National Marine Fisheries Service
J. C. Sweeney, D. R. Casper, J. S. Reif, F. Townsend, R. S. Wells, and Larry Hansen

An independent investigation of the Gulfarium's animal care programs and facility. Report submitted to the Gulfarium, Fort Walton Beach, Florida.
D. Casper, K. Ramirez

POSTER PRESENTATIONS

Sea Lion Anatomy and Patholgy: An Innovative New Website for Sharing Information between Stranding Network Participants:
David Casper, Melissa Miller, Sentiel (Butch) Rommel PhD, Dave Jessup, Leslie A. Dierauf, Frances Gulland PhD, MRCVS, Marty Haulena, Linda Lowenstine, Katie Colegrove, Tanja S. Zabka, Kathy Burek, Judy St. Leger, Beth Buckles, Jim Harvey PhD

Menigoencephalitis In Juvenile Salmon Sharks Associated With Carnobacterium Sp.:
C.R. Davis, B.D. Lifland, P.A. Schaffer, D.R. Casper, and S. Van Sommeran.

Monitoring Heat Flow In Dolphins: A New Method For Assessing Optimal Water Temperature
Casper. D., Rhinehart, H., Costa, D.

Initial Care And Stabilization Of A Stranded Pygmy Sperm Whale, Kogia Breviceps: A Team Approach
Rhinehart, H., Casper, D., Worthy, G.A.J., and Wells, M.

Adaptation of Human Immune Assays to Characterize Lymphocyte Function of the Bottlenose Dolphin
Garet P. Lahvis, Randall S. Wells, David Casper, Charles S. Via

BIOGRAPHICAL SKETCH

Provide the following information for the Senior/key personnel and other significant contributors.
Follow this format for each person. **DO NOT EXCEED FIVE PAGES.**

NAME: Christine Kreuder Johnson

eRA COMMONS USER NAME: CKREUDER-JOHNSON

POSITION TITLE: Professor of Epidemiology and Ecosystem Health

EDUCATION/TRAINING

INSTITUTION AND LOCATION	DEGREE	Completion Date	FIELD OF STUDY
University of California, Davis, California	PhD	00/2003	Epidemiology
University of California, Davis, California	MPVM	00/2000	Wildlife Epidemiology
University of Pennsylvania, Philadelphia, PA	VMD	05/1994	Veterinary Medicine
Duke University, Durham, North Carolina	BS	00/1990	Zoology/Political Science

A. Personal Statement

As Professor of Epidemiology, I am committed to advancing infectious disease investigations at the interface of animal, human, and environmental health through applied research that can inform public policy related to disease prevention and outbreak preparedness. Recent primary research activities investigate the environmental drivers influencing the ecology of infectious diseases emerging at the animal-human interface and patterns in transmission of zoonotic viruses, often in the international setting. For USAID's Emerging Pandemic Threats PREDICT program, I lead the optimization of surveillance activities in 30 resource-limited countries where we work in partnership with agricultural, wildlife, and public health sectors to inform on public health risk associated with zoonotic pathogens. This work has sought to establish an international network of scientists engaged in rigorous data collection to characterize risk of zoonotic disease transmission. For PREDICT, I have directed large-scale international grant activities in partnership with local clinics and hospitals to investigate fevers of unknown origin in patients, as well engage high-risk communities to concurrently sample people, livestock, and wildlife to detect viral sharing. Research has sought to strengthen disease detection capabilities for high priority zoonoses and understand the human dimensions of spillover, providing insight for behavior changes needed to mitigate risk and prevent epidemics. My most rewarding professional experiences often involve providing epidemiologic support to federal and state agencies to inform policy, including the California Department of Fish and Wildlife, US Fish and Wildlife Service, National Oceanic and Atmospheric Administration, the U.S. Agency for International Development, and the Department of Defense. To further advance epidemiologic solutions to complex problems at the interface of animal, human, and environmental health, I established the EpiCenter for Disease Dynamics, which uses data-driven approaches to model the dynamics of zoonotic pathogen spillover and spread.

As faculty at the university, I have developed new curriculum for health professionals and graduate students in one health, ecosystem health, and epidemiology. I lead a well-rounded graduate training program in wildlife epidemiology and disease dynamics with primary mentorship of over 20 graduate students and 11 post-doctoral scholars obtaining advanced training in epidemiology and disease ecology. With my supervision, trainees take an active role in optimizing study design, implementing field and laboratory activities, and undertaking advanced analytical challenges in their research. Trainees benefit from a collegial environment that supports diversity and encourages applied research activities in partnership with state, federal, and international agencies. All doctoral graduates have gone on to prominent agency leadership positions and faculty positions at top universities.

B. Positions and Honors

<u>Positions</u>

1995 – 1996 Associate Equine Veterinarian, Caldor Race Course, Griffith Equine Practice, Miramar, FL
1996 – 1999 Veterinarian/ Director of Research, Clinic for the Rehabilitation of Wildlife, Sanibel, FL
1998 – 2000 Associate Equine Veterinarian, Peninsula Equine, Palo Alto, CA
1999 – 2003 Post Graduate Researcher, Wildlife Health Center, School of Veterinary Medicine, University of California, Davis, CA
2003 – 2006 Wildlife Veterinarian, Wildlife Health Center, School of Veterinary Medicine, University of California, Davis, CA
2006 – present Professor of Epidemiology, Department of Medicine and Epidemiology, School of Veterinary Medicine, University of California, Davis, CA
2015 – present Director, EpiCenter for Disease Dynamics, Associate Director, One Health Institute, University of California, Davis, CA

<u>Honors</u>

2000 Peter J. Shields Fellowship Award
2001 California Coastal Environmental Quality Initiative Fellowship Award
2002 Morris Animal Foundation Fellowship Award
2008 Council Wildlife Disease Association
2012 Distinguished Faculty Teaching Award
2016 Chair of the Faculty, School of Veterinary Medicine
2017 UC Davis Academic Senate Distinguished Scholarly Public Service Award

C. Contributions to Science

1. Discovery of Emerging Infectious Diseases at the Animal-Human Interface

Interest in emerging infectious disease was sparked by the need for veterinarians with wildlife health expertise to inform on zoonotic diseases emerging from wild animal reservoirs. Early research activities began with evaluating risk of influenza transmission at high-risk human-animal interfaces in California, and my work has since expanded to large scale surveillance activities in over 35 countries in Asia, Africa, and Latin America to meet global health priorities. My work intersects animal and human health, with investigations typically focused on human populations with high levels of contact with wildlife, and wildlife populations with high levels of contact with humans. By design, my research activities seek to integrate multi-disciplinary expertise and next generation techniques in laboratory detection, social and behavioral sciences, and disease ecology. As co-Principal investigator for the Emerging Pandemic Threats PREDICT project for the past 10 years of project implementation, I have contributed to the design and implementation of the largest effort to date to investigate zoonotic virus spillover risk on a global scale. PREDICT works in close partnership with host country governments to strengthen capacity for detection of emerging infectious disease locally in resource-limited regions where advanced detection capabilities are needed most. Our work has enabled One Health partnerships in field surveillance, laboratory detection and pathogen discovery, and platforms for disease reporting that are closely coordinated with Ministries of Health, Ministries of Livestock, and Ministries of Wildlife.

a) Siembieda J, Johnson C, Boyce W, Sandrock C, Cardona C. Risk for avian influenza virus exposure at the human-wildlife interface. Emerging Infect Diseases, 14(7): 1151-3, 2008.
b) PREDICT Consortium. Reducing Pandemic Risk, Promoting Global Health. One Health Institute, University of California, Davis, December 2014. (http://www.vetmed.ucdavis.edu/ohi/local_resources/pdfs/predict-final-report.pdf)
c) Smiley Evans T, Tutaryebwa, Gilard KV, Barry PA , Marzi A, Eberhart M, Ssebide B, Cranfield MR, Mugisha O, Mugisha E, Kellermann S, Mazet JAK, Johnson CK . Suspected exposure to filoviruses among people contacting wildlife in Southwestern Uganda, The Journal of Infectious Diseases, jiy251. https://doi.org/10.1093/infdis/jiy251. 2018.
d) Goldstein T, Anthony SJ, Gbakima A, Bird BH, Bangura J, Tremeau-Bravard S, Belaganahalli MN, Wells H, Dhanota JK, Liang E, Grodus M, Jangra RX, Dejesus VA, Lasso G, Smith BR, Jambai A, Kamara BO, Kamara S, Bangura W, Monagin C, Shapira S, Johnson CK, Saylors K, Rubin EM, Chandran K, Lipkin WI,

Mazet JAK. The discovery of Bombali virus adds further support for bats as hosts of ebolaviruses. Nature Microbiology doi.org/10.1038/s41564-018-0227-2. 2018.

2. *Advancing Surveillance for Emerging Epidemic and Pandemic Threats*
My work has pioneered new approaches to surveillance targeting wildlife hosts for emerging infectious diseases. As Senior Personnel for Biological and Ecological Surveillance, for USAID's Emerging Pandemic Threats PREDICT project, I have led surveillance activities to detect viral threats in animals and humans in 30 countries. Field activities were designed to concurrently sample people, domestic animals, and wildlife, to identify viral sharing between species and characterize the evolutionary mechanisms and epidemiologic circumstances involved in disease transmission. Efforts to date have optimized best practices in surveillance design to detect cross-species disease transmission and identify reservoir hosts for emerging threats (such as ebolaviruses in West Africa). Faced with logistical hurdles in sampling difficult-to-handle wildlife species, we designed new non-invasive sampling techniques, evaluated and optimized these techniques in captive species for detection of a range of viral pathogens, and trained teams in Africa and Asia in implementation. We have designed outbreak investigations at the request of country governments to evaluate animal involvement in outbreaks in the public health sector and assist in outbreak response. We established new approaches to characterizing epidemics in animal reservoirs and suspected spillover hosts and have used these same techniques to characterize the epidemiology of outbreaks in terrestrial species and marine mammals involved in unusual morbidity and mortality events.

a) Smiley Evans, T, PA Barry, KV Gilardi, T Goldstein, JD Deere, J Fike, J Yee, BJ Ssebide, D Karmacharya, MR Cranfield, D Wolking, B Smith, J AK Mazet, and CK Johnson. Optimization of a novel non-invasive oral sampling technique for zoonotic pathogen surveillance in nonhuman primates. PLOS Neglected Tropical Diseases, 9(6), 2015.
b) Smiley Evan T, Gilardi KV, Barry PA, Ssebide BJ, Kinani JF, Nizeyimana F, Noheri JB, Byarugaba DK, Mudakikwa A, Cranfiedl MR, Mazet JA, Johnson CK. Detection of viruses using discarded plants from wild mountain gorillas and golden monkeys. American Journal of Primatology, 78(11): 1222-1234. 2016.
c) Siembieda JL, Hall AJ, Gulland FMD, Rowles T, Garron M, Matassa K, Rotstein DS, Gonzalez S, Northeast Region Marine Mammal Stranding Network, Johnson CK. Epidemiology of a phocine distemper virus outbreak along the North Atlantic Coast of the United States. Aquatic Mammals, 43(3): 254-263. 2017.
d) Kelly TK, Karesh WB, Johnson CK, Gilardi KV, Anthony S, Goldstein T, Olson S, Machalaba C, Mazet JK. One Health proof of concept: Bringing a transdisciplinary approach to surveillance for zoonotic viruses at the human-wild animal interface. Prev Vet Med, 137: 112-8. 2017.

3. *Epidemiological Modeling of Mechanisms Involved in Virus Spillover and Spread*
At the EpiCenter for Disease Dynamics, I lead a team of talented epidemiologists and modelers in the development of advanced computational methods to estimate the risk of spillover from wild animal hosts, highlight the transmission mechanisms and animal-to-human interfaces common to disease spillover, and estimate the magnitude of subsequent disease spread within at-risk human populations. To date, scientific outcomes have been tailored to assist the US Department of Defense in understanding outbreak risks and preparing for a range of outbreak responses and we have completed two contracts contributing data and applications to the Defense Threat Reduction Agency's Biosurveillance Ecosystem in the Chemical and Biological Technologies Department. Current initiatives integrate viral findings from PREDICT and data from all zoonotic viruses recognized to date to characterize species propensities to serve as a source of zoonotic spillover and enable risk prediction.

a) Johnson CK, PL Hitchens, T Smiley Evans, T Goldstein, K Thomas, A Clements, DO Joly, ND Wolfe, P Daszak, WB Karesh, JK Mazet. Spillover and pandemic properties of zoonotic viruses with high host plasticity. Scientific Reports. 5:14830. 2015.
b) Anthony, S, A Islam, CK Johnson, I Navarrete-Macias, E Liang, K Jain, P Hitchens, Xiaoyu Che, A Soloyvov, A Hicks, R Ojeda-Flores, C Zambrana-Torrelio, W Ulrich, M Rostal, A Petrosov, J Garcia, N Haider, N Wolfe, T Goldstein, S Morse, M Rahman, J Epstein, J Mazet, P Daszak, and W Lipkin. Non-random patterns in viral diversity. Nature Communications, 6: 8147. 2015.
c) Anthony SJ, Johnson CK, Greig DJ, Kramer S, Che X, Wells H, Hicks AL, Joly DO, Wolfe ND, Daszak P,

Karesh W, Lipkin WI, Morse SS, PREDICT Consortium, Mazet JAK, Goldstein T. Global patterns in coronavirus diversity. Virus Evol, 3(1): vex012. 2017.
d) Pandit P, Doyle M, Smart K, Young C, Drape G, Johnson CK. Predicting wildlife reservoirs and global vulnerability to zoonotic Flaviviruses. Nature Communications. 9:5424 2018.

4. Understanding Ecosystem-level Processes Impacting Wildlife Health
Research activities related to wildlife population health have sought to uncover ecosystem-level processes underlying patterns in disease at the population level. Examples below highlight multi-decadal population-wide studies conducted to understand processes promoting disease in sea otters, mountain lions, California condors, and other at-risk species. For these studies, new trans-disciplinary approaches were developed to integrate in-depth ecological data and advanced pathogen detection data to evaluate the influence of animal movements, behaviors, and diet choices on health and survivorship at the population scale. I have also served as primary mentor to graduate students training in epidemiology and disease ecology involved in this work.
a) Johnson CK, Tinker MT, Estes JA, Conrad PA, Staedler M, Miller MA, Jessup DA, Mazet JA. Prey choice and habitat use drive sea otter pathogen exposure in a resource-limited coastal system. Proceedings of the National Academy of Sciences, 106(7): 2242–7, 2009.
b) Vickers TW, Sanchez JN, Johnson CK, Morrison SA, Botta R, Smith T, Cohen BS, Huber PR, Ernest HB, Boyce WM. Survival and mortality of pumas (*Puma concolor*) in a fragmented, urbanizing landscape. PLoS One, 10(7): e0131490, 2015.
c) Vilchis, LI, Johnson, CK, Evenson, JR, Pearson, SF, Barry, KL, Davidson, P, Raphael, MG, Gaydos, JK. Assessing ecological correlates of marine bird declines to inform marine conservation. Conservation Biology, 29(1): 154-63, 2015.
d) Burgess T, Tinker T, Miller M, Bodkin J, Murray M, Saarinen J, Nichol L, Larson S, Conrad P, Johnson CK. Defining the risk landscape in the context of pathogen pollution: Toxoplasma gondii in sea otters along the Pacific Rim. R Soc Open Sci, 5(171178). 2018

5. *Informing Conservation and Wildlife Health Policy*
Activities in the area of wildlife conservation exemplify a strong commitment to informing state and federal agencies on disease risks to threatened wildlife species and serving pressing research needs at the boundaries of science and policy. As Principal Investigator, I have secured both state and federal wildlife agency funding for large-scale studies that can directly inform conservation and management of endangered wildlife projects. For these projects, I have ensured that research deliverables are tightly aligned with top agency priorities and involve multi-disciplinary teams with a diversity of expertise and perspectives as well as ongoing engagement of key stakeholders. Our work on condors was under intense public scrutiny because of the political implications associated with ammunition regulations, and we established a strong commitment to transparent scientific activities and data sharing. We found policy was well informed by consensus statements involving leading public health and toxicology scientists. These research activities have had direct implications for science-based policy and resulting legislation needed to mitigate pathogen pollution in sea otters and exposure to lead-based ammunition in California condors.
a) Johnson, CK, Kelly, TR, Rideout, BA. Lead in ammunition: a persistent threat to health and conservation. EcoHealth, 10(4): 455-64, 2013.
b) Kelly, TR, Grantham, J, George, D, Welch, A, Brandt, J, Burnett, LJ, Sorenson, KJ, Johnson, M, Poppenga, R, Moen, D, Rasico, J, Rivers, JW, Battistone, C, Johnson, CK. Spatiotemporal patterns and risk factors for lead exposure in endangered California condors during 15 years of reintroduction. Conservation Biology, 28(6): 1721-30, 2014.
c) Kelly, Terra R., et al. "Causes of mortality and unintentional poisoning in predatory and scavenging birds in California." *Veterinary Record Open* 1.1 (2014): e000028.
d) Kelly TR, Rideout BA, Grantham J, Brandt J, Burnett LJ, Sorenson KJ, George D, Welch A, Moen D, Rasico J, Johnson M, Battistone C, Johnson CK . Two decades of cumulative impacts to survivorship of endangered California condors in California. Biol Conserv, 191: 391-9. 2015.

Link to a complete list of publications https://scholar.google.com/citations?user=SCy6lAcAAAAJ&hl=en

D. Additional Information: Research Support (within the last 3 years)

Title: Emerging Pandemic Threats (EPT-2) Program PREDICT-2
Agency: US Agency for International Development
Scope: Investigation of viral threats at high-risk animal-human interfaces to strengthen pandemic preparedness in 30 resource limited countries at risk for emerging infectious diseases.
Date(s): 10/01/2014 – 09/30/2019

PI/Co-PI: Co-Principal Investigator, Jonna Mazet (PI)
Title: Modeling Health Capacity & Governance for Zoonotic Disease Outbreak Prediction
Agency: Department of Defense, Defense Threat Reduction Agency (subawardee to ENSCO)
Scope: Develop models to forecast outbreak size and risk of outbreak spread for select agents, accounting for variation in health capacity and governance of a given country/region
Date(s): 12/01/2015-11/30/2017
PI/Co-PI: Principal Investigator

Title: Data-Driven Framework for Zoonotic Disease Prediction
Agency: Department of Defense, Defense Threat Reduction Agency (subawardee to ENSCO)
Scope: Develop disease prediction models with automated access to datasets, data normalization, and data visualization of geospatial risk for select zoonotic viruses.
Date(s): 10/01/2014 – 09/30/2017
PI/Co-PI: Principal Investigator

Title: Enhanced Passive Surveillance for Wildlife Diseases in California
Agency: California Department of Fish and Wildlife
Scope: Establishes a network of wildlife responders and data entry system that detects unusual morbidity and mortality events and automatically characterizes potential outbreaks throughout the state of California, with built in reporting to the state wildlife agencies.
Date(s): 07/01/2014-06/30/2017
PI/Co-PI: Co-Principal Investigator, Terra Kelly (PI)

Title: EcoHealth Net 2.0: A One Health Approach to Disease Ecology Research & Education
Agency: National Science Foundation
Scope: A research collaboration grant that advances research in disease ecology by connecting trainees with research and mentoring opportunities in epidemiology, disease modeling, and emerging infectious disease research.
Date(s): 08/25/2016-08/31/2021
PI/Co-PI: Co-Principal Investigator, Jonathan Epstein (PI)

Title: Prediction of Spillover Potential and Interventional En Masse Animal Vaccination to Prevent Emerging Pathogen Threats in Current and Future Zones of US Military Operation
Agency: Defense Advanced Research Projects Agency
Amount: $9,669,372
Date(s): 10/1/2018 – 3/31/2022
PI/Co-PI: Peter Barry (lead), Brian Bird (Co-PI), Michael Jarvis (Co-PI), Scott Nuismer (Co-PI)
Role: Co-Investigator, Subject Matter Expert

Title: Exploration of novel biomarkers for repeated domoic acid exposure and associated chronic health impacts in at-risk southern sea otters (*Enhydra lutris nereis*)
Agency: Oiled Wildlife Care Network
Amount: $63,272
Date(s): 7/1/2018 – 6/31/2019
PI/Co-PI: Principal Investigator

Bio-Bibliography
University of California, Santa Cruz, CA
DANIEL PAUL COSTA

EMPLOYMENT

2016-	**SSC IMBER**-Integrated Marine Biogeochemistry & Ecosystem Research
2011	Distinguished Professor of Ecology and Evolutionary Biology Step IX above scale
2011-2017	**SOOS**-Southern Ocean Observing System Science Steering Committee
2010-2014	Member Central and Northern California Ocean Observing System, CENCOOS Council
2009-2013	Member **ORRAP-**Ocean Resources and Research Advisory Panel
2009-present	Science Steering Committee **ICED**- Integrated Climate & Ecosystem Dynamics
2009-2017	Science Steering Committee **CLIOTOP**- Climate Change & Top Predators
2008-2013	Ida Benson Endowed chair of Ocean Health
2007	Professor of Ecology and Evolutionary Biology Step IX
2005	Professor of Ecology and Evolutionary Biology Step VII
2002	Professor of Ecology and Evolutionary Biology Step VI
2001 & 2002	Chief Scientist Southern Ocean **GLOBEC** Process Cruise. July-August
2002-2006	Secretary Society of Marine Mammalogy
2000-2011	Steering Committee Southern Ocean **GLOBEC**
1999	Zoologist in Residence, University of Tasmania, Hobart, Australia
1995-97	Associate Director, Institute of Marine Sciences
1994-97	Associate Chair of Biology
1993-	Professor of Biology
1991-93	Scientific Officer, Physiology and Marine Mammal Biology Office of Naval Research, Arlington, Virginia
	Associate Professor of Biology
1988-90	Associate Adjunct Professor of Biology and Marine Science
1989	June through September, U.S. Navy - ASEE Senior Faculty Fellow, Naval Oceans Systems Center, Kaneohe, Hawaii
1986-88	Associate Research Biologist, University of California, Santa Cruz
1983-86	Assistant Research Biologist, University of California, Santa Cruz
1987	November, Visiting Scientist, British Antarctic Survey, Cambridge, England
	July through September, U.S. Navy - ASEE Senior Faculty Fellow, Naval Oceans Systems Center, Kaneohe, Hawaii
	April through June, Visiting Scientist, Abteilung Wickler, Max-Planck Institut für Verhaltensphysiologie, Seewiesen, West Germany.
1985	August and September, Visiting Scientist, British Antarctic Survey, Cambridge England
1979-82	National Institutes of Health Postdoctoral Fellowship, Physiological Research Laboratory, Scripps Institution Oceanography
1978-82	Postdoctoral Research Physiologist Scripps Institution Oceanography
1977-78	Staff Research Associate, Scripps Institution Oceanography
1977	Teaching Assistant, Biology, University of California, Santa Cruz
1976	Research Assistant, University of California, Santa Cruz
1975	Teaching Assistant, Biology, University of California, Santa Cruz
1974	Laboratory Assistant, Laboratory of Nuclear Medicine and Radiation Biology, University of California, Los Angeles

EDUCATION

1978-1982	Scripps Institution of Oceanography, Postdoctoral Physiologist
1978	University of California, Santa Cruz, Ph.D. (Biology)
1974	University of California, Los Angeles, B.A. (Zoology, Honors) Cum Laude

MEMBERSHIPS IN HONORARY SOCIETIES

Fellow, California Academy of Sciences
American Geophysical Union
American Society of Limnology & Oceanography
American Physiological Society
American Society of Mammalogists
Society of Integrative and Comparative Biology
Ecological Society of America
Society of Marine Mammalogy
Acoustical Society of America
Sigma Xi

HONORS, AWARDS & GRANTS

2018 Developing Metrics of Animal Condition and their linkage to Vital Rates: Further Development of the PCoD Model: Office of Naval Research, Aug 1, 2018 July 31, 2021 [redacted].

Joint Industry Programme on E&P Sound and Marine Life - Phase III, Towards a Risk Assessment Framework/Protocol for Implementing the Data-Driven Population Consequences of (Acoustic) Disturbance (PCAD/PCoD) Model/Approach. 7/1/2018 – 12/31/2020. [redacted]

2017 'PCoD+: Developing widely-applicable models of the population consequences. Sub-award St Andrews University, Prime Office of Naval Research 1/1/17 -12/31/20, [redacted]

Collaborative Research: Foraging Ecology and Physiology of the Leopard Seal. NSF Polar Programs, October 1 2017- Sept 31 2020. [redacted]

Collaborative Research: At-sea experimental disturbances to characterize physiological plasticity in diving northern elephant seals, MLML prime NSF Integrative Biology August 15, 2017 to July 31, 2021. [redacted]

Investigating the foraging behavior of a large predator, the northern elephant, UC Mexus, 1/1/17 - 12/31/18 [redacted]

2016 Development of the PCAD Model to Assess Biological Significance of Acoustic Disturbance. Office of Naval Research Jan – Dec 2018,[redacted]509.

2015 Unraveling the Genomic and Molecular Basis of the Dive Response, Massachusetts General Hospital, Office of Polar Programs NSF 7/15/15-6/30/18. [redacted].

Marine energy harvesting for remote system operational expansion. sub-award from Northern Arizona University, funding agency NSF Ocean Technology and Interdisciplinary Coordination (OTIC) 9/16/15-8/31/18, [redacted]

2014 A Bioenergetic Model to Estimate the Population Consequences of Disturbance. Marine Life Joint Industry Program, Sept 2014 –June 2018. [redacted]

2013 Retrospective Analysis of Antarctic Tracking Data (RAATD): International Crabeater and Weddell Seal Tracking Data Sets. 3/1/2013-2/28/2015 [redacted] Office of Polar Programs National Science Foundation.

2012 Application of the PCAD Model to the California Gray Whale, Integration of Existing Data and Towards a Quantitative Assessment of Biological Significance of Acoustic Disturbance. Joint Award Shell America Upstream and ExxonMobil Research Company. Nov 1 2012-Sept 31 2014. $[redacted]

Development of the PCAD Model to Assess Biological Significance of Acoustic Disturbance. October 1 2012- September 31 2015. Office of Naval Research. $[redacted]

2010 Environmental perturbations, behavioral change, and population response in a long-term northern elephant seal study. 1/1/2010-12/31/2012, [redacted]. Office of Naval Research.

Phase III Tagging of Pacific Pelagics. Alfred P. Sloan Foundation, 1/1/2010-12/31-2010, [redacted]

2009-2013 ORRAP Ocean Research Advisory Panel, Appointed by the Secretary of the Navy

Collaborative Research: Weddell seals as autonomous sensors of the winter oceanography of the Ross Sea, 7/1/2009 -6/30/2013, [redacted] Office of Polar Programs, National Science Foundation.

2008-2013 Ida Benson Endowed Chair of Ocean Health

Eminent Scholars Lecture, University of South Florida February 2008.

Use of electronic tag data and associated analytical tools to identify and predict habitat utilization of marine mammals, [redacted]. 8/2008-8/2011. Office of Naval Research

Relating Behavior and Life Functions to Populations Level Effects in Marine Mammals: An empirical and modeling effort to develop the PCAD model. 3/2008-2/2010. [redacted]. Marine Life Joint Industry Program.

2007 TOPP Phase III: Pilot Projects Involving Birds and Marine Mammals 2007-2009. [redacted] 5/2007-4/2009 Packard Foundation.

Mapping Hot Spots in California Current and Advancing Archival Tag Technology. [redacted], 12/2007- 6/2009. Gordon and Betty Moore Foundation.

Tagging of Pacific Pelagics: Identifying and Conserving Pacific Hot Spots in the California Current. 4/2007-3/2010. Alfred P Sloan Foundation

2006 Collaborative Research: U.S. SO GLOBEC Synthesis and Modeling - Habitat Utilization and Predator-Prey interaction in Western Antarctic Peninsula. NSF Polar Programs $[redacted]9/06-8/08.

From Wind to Whales: The Center for Integrated Marine Technologies to Understand California. [redacted]. NOAA-Center for Integrated Marine Technology. 08/01/06-07/30/07.

Costa Spur Antarctica. Feature on the Antarctic Continent named in recognition of the contribution of D. Costa to Antarctic Research.

2005 Elephant seals as ocean sensors in polar regions. National Undersea Research Program-NOAA. [redacted] 3/05-01/06.

Habitat Utilization of Southern Ocean Seals: Foraging Behavior of Crabeater and Elephant Seals Using Novel Methods of Oceanographic Data Collection. NSF Polar Programs. [redacted]. 8/05-7/08.

Understanding Apex Predator and Pelagic Fish Habitat Utilization in the California Current System by Integrating Animal Tracking with in situ Oceanographic Observations. National Oceanographic Partnership Program ONR. [redacted] 4/05-04/08.

2004 ***The Census of*** *Marine Life Project* Tagging of Pacific Pelagics Phase II: Pilot Demonstration Projects, Data Management, Education and Outreach. Packard Foundation 6/04-05/07 [redacted] Co PI with B. Block at Stanford University.

Foraging Ecology of the California Sea Lion: Diet, Diving Behavior, Foraging Locations and Predation Impacts on Fishery Resources. [redacted] California Sea Grant College Program 9/04-8/06.

Tagging Of Pacific Pelagics Phase II, Gordon and Betty Moore Foundation 7/04-06/07 [redacted] Co PI with B. Block at Stanford University.

Tagging of Pacific Pelagics: Using Organisms as Bioprobes for the Ocean Environment. NOAA Office of Ocean Exploration. [redacted]07/01/04-06/30/05.

2003 TOPP Phase II: Infrastructure, Data Management and International Collaboration 2003-2005. [redacted]. Alfred P Sloan Foundation. 07/01/03-06/30/06**.** Co PI with B. Block at Stanford University.

2002-2006 Secretary Society of Marine Mammalogy

2002 From Wind to Whales: The Center for Integrated Marine Technologies to Understand California. $[redacted] NOAA-Center for Integrated Marine Technology. 08/01/02-07/30/05.

Accelerating Electronic Tag Development for tracking Free-Ranging Marine Animals at Sea. National Oceanographic Partnership Program (NOPP), Office of Naval Research. [redacted] 4/02-3/05.

Tagging of Pacific Pelagics. Packard and Sloan Foundation $[redacted] 9/2001-6/2003.

2000 Foraging ecology of crabeater seals (*Lobodon carcinophagus*). National Science Foundation, Division of Polar Programs [redacted] January 2001- June 2004.

A data base for the study of marine mammal behavior: A tool to define their critical habitat and behavior. Office of Naval Research. $[redacted] 8/1/00-9/31/02

1999 Comparative Foraging Ecology of the Australian Sea Lion and New Zealand Fur Seal. National Geographic Society. [redacted].

Tools of the Assessment of Marine Mammal Critical Habitats. Office of Naval Research, 6/1/99 - 5/31/02, [redacted]

Dissertation Research: Foraging Ecology of Procellariiform Seabirds: Impacts on Reproduction and Life History. National Science Foundation, 2/1/99 - 1/31/00, [redacted]

Foraging Ecology of Wandering Albatrosses, *Diomedea exulans.* National Science Foundation, Division of International Programs, 2/1/99 – 1/31/01, [redacted].

1998 Biological Oceanography and Foraging Ecology of Northern Elephant Seals: Patch Use and the Relationship to Oceanographic Features and Elephant seals as a Biological Autonomous Underwater Sampling System. Institute of Marine Sciences, Packard Endowment for Ocean Science and Technology, [redacted]

Acoustic Ecology and Remote Acoustic Monitoring of a Minke Whale Population. Office of Naval Research, 7/25/98 - 9/30/99, [redacted]

University Research Support for High School Science, Subcontract from CSUMB, National Science Foundation, 9/98 - 5/00, [redacted]

Foraging Energetics of Male and Female Wandering Albatross, *Diomedea exulans.* National Geographic Society, [redacted]

The role of oceanographic features and prey distribution on foraging energetics and reproductive success of the Antarctic fur seal, *Arctocephalus gazella*. National Science Foundation, Division of Polar Program Antarctic Biology, 9/1/98 - 8/31/01 [redacted]

The Effect of the 1997/98 El Niño on U.S. Coastal areas. National Oceanic and Atmospheric Administration, 2/19/98 - 2/18/99, [redacted].

1996 Marine Mammal Studies in the Central California National Marine Sanctuaries. National Oceanic and Atmospheric Administration, Marine Sanctuaries Program, [redacted]

Elected Fellow, California Academy of Sciences.

1995 The Importance of Foraging Pattern of Reproductive Success in the Northern Fur Seal, *Callorhinus ursinus*. National Science Foundation, Division of Polar Program Arctic Biology, 6/95 - 5/98, [redacted]

Office of Naval Research, AASERT award for graduate student research support. 5/95 - 4/98, [redacted].

1994 Nominated by White House to serve as U.S. Commissioner on the Inter-American Tropical Tuna Commission.

The Physiology of Freely Diving Beluga Whales. Office of Naval Research, 9/94 - 8/97, [redacted]

Scripps Institution of Oceanography, Marine Mammal Research Program component of Acoustic Thermometry of the Ocean Climate (ATOC), 2/94 - 9/96, [redacted].

1993 The Low Frequency Sound Marine Environment of the Northern Elephant Seal. Office of Naval Research, 1/94 - 12/97 [redacted]

1992 Seed Money Award, Dean Graduate and Research Division, UCSC, [redacted]

1991 Nominated for Member at Large, Society for Marine Mammalogy.

1990 Free-Ranging Energetics of the Bottlenose Dolphin. National Science Foundation, Biological Oceanography, 6/91 - 7/93, [redacted]

Ground Truth of Sea Otter Boat Surveys. U.S. Dept. of Justice, August 1990, [redacted]

Research in Pinniped Biology and Cognition and Physiology. Center for Field Studies, 6/90 - 5/91, [redacted]

Foraging Energetics of Australian Sea Lions. National Geographic Society, 12/89 - 12/90, $1[redacted]

1989 Research in Marine Mammal Behavior Cognition and Physiology. Center for Field Studies, 6/89 - 5/90, [redacted]0.

Senior Summer Faculty Fellowship, U.S. Navy, American Association Engineering Education, [redacted].

1988 Seed Money Award, Dean Graduate and Research Division, UCSC, [redacted]

1987 Senior Summer Faculty Fellowship, U.S. Navy, American Association Engineering Education, [redacted]

Nutritional Energetics and Thermal Requirements of Marine Mammals. Office of Naval Research, 2/87 - 1/90, [redacted]

Bioenergetics of the Antarctic Fur Seal. National Science Foundation, Polar Programs, [redacted]

[redacted] Opportunity Award, Dean, Division of Natural Sciences, UCSC[redacted].

Foraging Biology of the Little Penguin in Australia. University Research Expeditions, UREP Grant, [redacted].

Nominated for Secretary-Treasurer, Society for Marine Mammalogy.

Current Methods in Pinniped Bioenergetics. National Science Foundation, Physiological Ecology Symposium, 1/86 - 12/86, [redacted].

1985 Studies of the Energetic Cost of Net Entanglement of Northern Fur Seals in Marine Debris. National Oceanic and Atmospheric Organization, NMFS, 9/85 - 9/86, [redacted]

Research Opportunity Award, Dean, Division of Natural Science, UCSC, [redacted].

1984 Foraging Energetics of the Little Penguins in Australia. University Research Expeditions Program, UREP Grant, [redacted]

1983-86 Assessment of the Impact of the California Sea Lion and Elephant Seal on Commercial Fisheries. California Sea Grant College Program, 10/83 - 9/86, $[redacted].

California Sea Grant College Program, Graduate traineeship, 10/83 - 9/86, [redacted]

Bioenergetics of the Antarctic Fur Seal. National Science Foundation, Polar Programs, 9/83 - 2/86, [redacted].

1981-83 Bioenergetics of the Northern Fur Seal, *Callorhinus ursinus*. National Oceanic and Atmospheric Organization, National Marine Fisheries Service, 6/81 - 5/83[redacted]64.

1979-82 Bioenergetics of Fasting and Lactation in the Fur Seal and Elephant Seal. National Institutes of Health Postdoctoral Research Fellowship, 9/79 - 9/82, [redacted].

1979 Antarctic Service Medal.

1978-80 Effects of Oil Contamination on Free-Ranging Sea Otters, *Enhydra lutris*. National Oceanic and Atmospheric Administration, Outer Continental Shelf Environmental Assessment Program, 10/78 - 6/80, [redacted]

1977 Prize of Excellence, 58th Annual Meeting AAAS Pacific Division for paper entitled, "Ecological Energetics of the California Sea Otter."

1976-77 Ecological Energetics of the California Sea Otter, *Enhydra lutris*. U.S. Fish and Wildlife Service, 4/76 - 5/77, $[redacted]

1975-77 Graduate Fellowship, California State Scholarship and Loan Commission.

1970 Bausch and Lomb Science Award.

PATENTS

None

PUBLICATIONS

<u>Papers Published:</u>

Jackson-Ricketts, J., R. I. Ruiz-Cooley, C. Junchompoo, S. Thongsukdee, A. Intongkham, S. Ninwat, K. Kittiwattanawong, E. M. Hines, D. P. Costa. 2018. Ontogenetic Variation in Diet and Habitat of Irrawaddy Dolphins (Orcaella brevirostris) in the Gulf of Thailand and the Andaman Sea. Marine Mammal Science: in press.

Abrahms, B., K. L. Scales, E. L. Hazen, S. J. Bograd, R. Schick, P. W. Robinson, and D. P. Costa. 2018. Mesoscale activity facilitates energy gain in a top predator. Proceedings Royal Society of London Series B Biological Sciences 285:1885

Abrahms, B., E. L. Hazen, S. J. Bograd, J. S. Brashares, P. W. Robinson, K. L. Scales, D. E. Crocker, and D. P. Costa. 2018. Climate mediates the success of migration strategies in a marine predator. Ecol Lett **21**:63-71.

Bagchi, A., A. J. Batten, M. Levin, K. N. Allen, M. L. Fitzgerald, L. A. Hückstädt, D. P. Costa, E. S. Buys, and A. G. Hindle. 2018. Intrinsic anti-inflammatory properties in the serum of two species of deep-diving seal. The Journal of Experimental Biology **221**. doi:10.1242/jeb.178491

Briscoe, D. K., S. Fossette, K. L. Scales, E. L. Hazen, S. J. Bograd, S. M. Maxwell, E. A. McHuron, P. W. Robinson, C. Kuhn, D. P. Costa, L. B. Crowder, and R. L. Lewison. 2018. Characterizing habitat suitability for a central-place forager in a dynamic marine environment. Ecol Evol **8**:2788-2801.

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Costa, D.P. 1991. Reproductive and foraging energetics of pinnipeds: Implications for life history patterns. In: *Pinniped Behaviour*, D. Renouf, ed. Chapman Hall (ITP): Florence, Kentucky; pp. 301-344.

Costa, D.P. 1987. Isotopic methods for quantifying material and energy intake of free-ranging marine mammals. In: *Approaches to Marine Mammal Energetics*. A.C. Huntley, D.P. Costa, G.A.J. Worthy and M.A. Castellini, eds. Allen Press: Lawrence, Kansas; pp. 43-66.

Costa, D.P. and Gentry, R.L. 1986. Ch. 5. Free-ranging energetics of northern fur seals, *Callorhinus ursinus*. In: *Fur Seals: Maternal Strategies on Land and at Sea*. R.L. Gentry and G.L. Kooyman, eds. Princeton University Press: Princeton, New Jersey; pp. 79-101.

Gentry, R.L., Costa, D.P., Croxall, J.P., David, J.H.M., Davis, R.W., Kooyman, G.L., Majluf, P., McCann, T.S., and Trillmich, F. 1986. Ch.15 Synthesis and conclusions. In: *Fur Seals: Maternal Strategies on Land and at Sea*. R.L. Gentry and G.L. Kooyman eds., Princeton University Press: Princeton, New Jersey; pp. 220-264.

Braham, H.W., Oliver, G.W., Fowler, C., Frost, K., Fay, F., Cowles, C., Costa, D., Schneider, K., and Calkins, D. 1982. Chapter 4. Marine mammals. In: *The St. George Basin Environment and Possible Consequences of Planned Offshore Oil and Gas Development*, M.J. Hameedi ed., OCSEAP U.S. Dept. Of Commerce: Juneau, Alaska; pp. Pages 55-81.

Book Reviews

Other Publications from Costa's Laboratory

Shaffer, S. A. 2004. Annual energy budget and food requirements of breeding Wandering Albatrosses (*Diomedea exulans*). Polar Biology 27:253-256.

Shaffer, S. A. 2003. Eye of the albatross: visions of hope and survival by Carl Safina - A review. Marine Ornithology 31: 92.

Angelier, F., Shaffer, S. A., Weimerskirch, H., and Chastel, O. 2006. Effect of age, breeding experience and senescence on corticosterone and prolactin levels in a long-lived seabird: the wandering albatross. General and Comparative Endocrinology 149:1-9.

Baker, J. D. and Donohue, M.J. 2000. Ontogeny of swimming and diving in northern fur seal (*Callorhinus ursinus*) pups. Canadian Journal of Zoology 78(1): 100-109.

Publications with Reference to Costa, D.P.

Knight, K. 2018. Collapsing seal lungs protected by amazing anti-inflammatory blood serum. The Journal of Experimental Biology **221**.

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Sea Animals Get Tagged for Double-Duty Research. 2006. Science 313:1383-1384.

Wanderers on the Ocean Wind. 2002. National Geographic September 2001

Online marine resources could soon be swimming with data. 2002. Nature 415:4

Minke Whales make Star Wars noises. 2001. Science News 159:376

Technical Reports

Costa, D.P. 2001. Report of R/V Lawrence M. Gould Cruise LMG01-06 to the Western Antarctic Peninsula 21 July to 1 September 2001, United States Southern Ocean Global Ocean Ecosystems Dynamics Program, Report Number 3, Old Dominion University Norfolk, VA

Costa, D.P. 2002. Report of R/V Lawrence M. Gould Cruise LMG01-06 to the Western Antarctic Peninsula 29 July to 19 September 2002 United States Southern Ocean Global Ocean Ecosystems Dynamics Program, Report Number 7, Old Dominion University Norfolk, VA

Block, B., Costa, D., Boehlert, G. and Kochevar, R. 2001. A report on the tagging of Pacific pelagics (TOPP) workshop. A pilot project for the census of marine life, Monterey California, November 12-14, 2000.

Costa, D.P. 1988. Assessment of the impact of the California sea lion and northern elephant seal on commercial fisheries. Pages 36-43. In: *California Sea Grant: Biennial Report of Completed Projects 1984-86*. California Sea Grant College Program, University of California, La Jolla Publication # R-CSCP-024.

Graduate Students:

Student	Department	Degree Program	Year	Co-Sponsor
Kelly Keen	EE.Biology	Ph.D.	2018-	
Theresa Tatom-Naecker	EE Biology	Ph.D.	2018-	R. Wells
Theresa Keates	Ocean Sciences	Ph.D.	2018	
Jessica Kendall-Bar	EE Biology	Ph.D.	2017-	T. Williams
Arina Favella	EE Biology	Ph.D.	2017-	
Logan Palin	EE Biology	Ph.D.	2017-	A. Friedlander
Michelle Modest	EE Biology	Ph.D.	2017-	A. Friedlander
Theresa Keates	Ocean Sciences	MSc (2018)	2016-2018	
Rachel Holser	EE Biology	Ph.D.	2014-	
Sarah Kienle	EE Biology	Ph.D.	2013-	R. Mehta
Caroline Casey	EE Biology	Ph.D. (2018)	2013-2018	C. Reichmuth
Elizabeth McHuron	EE Biology	Ph.D. (2016)	2012-2016	
Claudio Rojas	EE Biology	Ph.D.	2011-2016	
Michael Tift	EE Biology	Ph.D.	2011-12	
Justine Jackson-Ricketts	EE Biology	Ph.D. (2017)	2010-17	
Sarah Peterson	EE Biology	Ph.D. (2015)	2010-2015	
Melinda Connors	Ocean Science	Ph.D. (2015)	2009-2015	Shaffer
Chandra Goetsch	EE Biology	Ph.D. (2018)	2009-2018	
Kim Goetz	EE Biology	Ph.D. (2015)	2009-2015	
Nicole Teutschel	EE Biology	M.A.	2009-2010	
Melinda Fowler	EE Biology	Ph.D. (2012)	2007-2012	Crocker
Jennifer Maresh	EE Biology	Ph.D. (2014)	2005-2014	Williams
Luis Huckstadt	Ocean Science	Ph.D. (2012)	2005-2012	
Sara Maxwell	Ocean Science	Ph.D. (2010)	2005-2010	
Cory Champagne	EE Biology	Ph.D. (2011)	2005-2011	Crocker
Michelle Kappes (Antolos)	EE Biology	Ph.D. (2009)	2005-2009	Shaffer
Autumn-Lynn Harrison	EE Biology	Ph.D. (2012)	2005- 2012	
Stella Villegas	EE Biology	Ph.D. (2009)	2004-2009	
Birgette McDonald	EE Biology	Ph.D. (2009)	2004-2009	

Patrick Robinson	EE Biology	Ph.D. (2009)	2004-2009	
Andreas Walli	Ocean Science	Ph.D. (2007)	2004-2007	
Jason Hassrick	EE Biology	Ph.D. (2011)	2004-2011	
Samantha Simmons	EE Biology	Ph.D. (2008)	2003-2008	
Samantha Simmons	Ocean Science	M.Sc (2003)	2001-2003	
Michael Weise	EE Biology	Ph.D. (2006)	2001-2006	
Christopher Lester	EE Biology	M.A. (2004)	2001-2004	
Carey Kuhn	EE Biology	Ph.D. (2006)	1999-2006	
Shannon Fowler	EE Biology	Ph.D. (2005)	1999-2005	
Mary Cashman	EE Biology	M.A. (2003)	2000-2002	
Jason Gedamke	Ocean Science	Ph.D. (2004)	1997-2004	
Jill Pettinger	Ocean Science	MSc. (2000)	1997-2000	B. Le Boeuf
Scott Schaffer	Biology	Ph.D. (2000)	1996- 2000	T. Williams
Sylvia Laano	Biology	Ph.D.	1995-97	T. Williams
Mary Donohue	Biology	Ph.D. (1998)	1995-98	
Mary Donohue	Biology	M.A. (1997)		
Scott Shaffer	Marine Science	M.Sc (1996)	1994-96	T. Williams
Tristin Moore	Marine Science	M.Sc (1998)	1994-97	R. Wells
Jennifer Jolly	Marine Science	MSc (1997)	1994-97	B. Le Boeuf
Karen Morris	Biology	M.A. (1998)	1994-97	B. Le Boeuf
Sean Hayes	Biology	Ph.D. (2003)	1994-2002	B. Le Boeuf
Sean Hayes	Biology	M.A. (1998)		
Dorian Houser	Biology	Ph.D. (1999)	1994-98	
Paul Webb	Biology	Ph.D. (1999)	1994-99	B. Le Boeuf
Greg Golet	Biology	Ph.D. (2000)	1994-99	J. Estes
Michael Goebel	Biology	Ph.D. (2003)	1993-1998	
Dan Munson	Marine Science	MSc. (1995)	1992-95	J. Estes
Jocelyn Vedder	Marine Science	MSc (1996)	1992-96	R. Wells
Maria Kretzman	Biology	Ph.D. (1998)	1991-98	B. Rice
Dan Crocker	Biology	Ph.D. (1995)	1991-95	B. Le Boeuf
Jennifer Hurley	Biology	Ph.D. (1996)	1991-96	
Danielle Waples	Marine Science	MSc (1996)	1991-95	R. Wells
Paul Webb	Marine Science	MSc (1994)	1991-94	B. Le Boeuf
Nancy Naslund	Marine Science	MSc (1993)	1989-93	
Jeannine Williams	Biology	Ph.D. (1995)	1989-95	
Dan Crocker	Marine Science	MSc (1992)	1989-92	B. Le Boeuf
Alexis Barbour	Marine Science	MSc (1993)	1989-93	
David Dorado	Biology	Ph.D.	1988-92 (M.A.)	
Sean Adams	Marine Science	MSc (1990)	1988-90	
John A. Liao	Marine Science	MSc (1990)	1987-90	
Lorrie D. Rea	Marine Science	MSc (1990)	1987-90	
Maria Kretzmann	Marine Science	MSc (1990)	1987-90	
Lesley Higgins	Biology	Ph.D. (1991)	1986-91	K. Norris
Brian S. Fadely	Marine Science	MSc (1989)	1986-88	
David Murnane	Marine Science	Masters	1985-87	

Postdoctoral Fellows:

Dr. Roxanne Beltran	2018-present
Dr. Elizabeth McHuron	2016-2017
Dr. Jen Maresh	2014-2016
Dr. Stella Villegas-	2013-2017
Dr. Luis Huckstadt	2012-present
Dr. Sara Maxwell	2010-2011
Dr. Patrick Robinson	2009-2012
Dr. Greg Breed	2009-2011
Dr. Lisa Schwarz	2009-2014
Dr. Gitte McDonald	2009-2010
Dr. Samantha Simmons	2008-2009
Dr. Carey Kuhn	2006-2007
Dr. Mike Weise	2006-2008
Dr. Ken Yoda	2005-2007
Dr. Yoko Mitani	2004-2006
Dr. Yann Tremblay	2003-2008
Dr. Scott Shaffer	2000-2004
Dr. Kelly Jaakola	1997-99
Dr. Jennifer Burns	1997-2000
Dr. Jennifer Hurley	1996-97
Dr. Dawn Goley	1996-97
Dr. Daniel Crocker	1995-97
Dr. Lesley Higgins	1994-96
Dr. Lorrie Wickham	1992-94
Dr. Steve Feldkamp	1986-88
Dr. Graham Worthy	1987-90

Michael D. Harris, Senior Environmental Scientist (Specialist)
California Department of Fish and Wildlife
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Office: 805.772.1135
Michael.D.Harris@Wildlife.Ca.Gov

PROFESSIONAL EXPERIENCE

April 2012-present: California Department of Fish and Wildlife, Morro Bay California
Senior Environmental Scientist (Specialist). Provide expertise and management of the State's sea otter field research program. Develop and conduct complex investigations and analysis of environmental issues in relation to oil spills, spills of other pollutants and associated impacts on sea otters and other marine sentinel species. Manage CDFW's monitoring program for recovery of dead sea otters and other sentinel species, and participates in postmortem examination of the dead animals. As the Department's sea otter expert, participated in development and operation of the marine ecosystem health program for coastal California in cooperation with other State, federal agencies, and universities. Manage the State's role in the capture, tagging and sampling of sea otters and other marine vertebrates as needed for research and management actions, including but not limited to those resulting from pollution incidents or chronic releases of chemical and biological pollutants into the environment. Duties require maintenance of SCUBA and CCR-100% oxygen rebreather diving certification.

June 2001-April 2012: California Department of Fish and Game, Morro Bay, California
Environmental Scientist C. Under direction of the Office of Spill Prevention and Response, Veterinary Services, develop and conduct complex investigations and analysis of environmental issues in relation to oil spills, spills of other pollutants and associated impacts on sea otters and other marine sentinel species. Develop, perform and report on GIS-based aerial, boat and ground surveys for species sensitive to oil in the environment; perform sea otter and sentinel species carcass recovery and postmortem examination; perform capture, sampling and marking of sensitive species (emphasis on sea otters); perform all aspects of wildlife oil spill response, and maintain oil spill response equipment including boats and specialized wildlife capture and rescue equipment. Produce presentations and reports. CDFG-certified SCUBA and rebreather diver.

July 1997 to June 2001: Calif. Department of Fish and Game (contract), Morro Bay, California
Sea Otter Biologist. Coordinate and conduct studies on sea otter biology and natural history pertinent to conservation and management issues, including population dynamics, population health assessment, food habits, natural resource damage assessment, and fishery interactions. Assist CDFG Vet Services with oil spill response involving wildlife. Produce presentations and reports. CDFG-certified SCUBA and Rebreather diver.

August 1991 to June 1997: California Department of Fish and Game, Morro Bay, California
Scientific Aid. Sea Otter Research Project. Perform studies on sea otter biology and natural history pertinent to natural resource damage assessment, conservation and management issues including population dynamics, mortality, food habits, and fishery interactions. Produce presentations and reports.

July 1995 to June 2001: United States Fish and Wildlife Service (contract), Ventura, California
Marine Biologist. Coordinate sea otter mortality study activities in southern portion of their range.

March 1995 to 2000: Coastal Resources Management (contract), Corona del Mar, California
Marine Biologist. Conduct diving surveys assessing impacts on eelgrass communities from dredging and construction projects; implement and monitor mitigation measures. Conduct subtidal surveys of nearshore benthic communities affected by construction and operation of a desalination plant. Provide consultation on impacts to sea otters from described projects.

August 1996 to July 1998: Tenera, Avila Beach, California
Senior Research Associate. Perform intertidal and diving surveys of benthic marine communities to assess operation affects of a nuclear power plant.

February 1995 to July 1996: Entrix Environmental, Walnut Creek, California
Environmental Technician. Conducted field surveys assessing impacts from petroleum products on intertidal and subtidal marine communities.

October 1994 to March 1995: Science Applications International Corporation, S.B., California
Marine Biologist. Provided consultation on impacts to sea otters from installation of the nearshore leg of a trans-Pacific telephone cable. Monitored project activities within sea otter habitat and provided written report.

May 1991 to December 1993: Hanson Environmental, Walnut Creek, California
Fisheries Technician. Conducted fishery surveys and habitat mapping of the Santa Ynez River. Conducted thermotolerance experiments on fingerling Chinook salmon.

EDUCATION

California Polytechnic State University, San Luis Obispo. Bachelor of Science in Biological Sciences, concentrating in Marine Biology, December 1990.

PUBLICATIONS AND TECHNICAL REPORTS

2015 Tinker, M. T., Hatfield, B.B., **Harris, M. D**., Ames, J.A. Dramatic increase in sea otter mortality from white shark in California. Marine Mammal Science. 32(1): 309-326.

2014 Henkel, L., **Harris, M.D.**, Ames, J., Ford, R.G., Staedler, M., Tinker, M.T. Use of decoys to assess effectiveness of aerial surveys for sea otters. California Department of Fish and Wildlife, Office of Spill Prevention and Response Technical Report 14-2.

2013 Miller, M.A., Dodd, E., Batac, F., Young, C., **Harris, M.D**., Kunz, J., Berberich, E., Henkel, L**.** Summary of Southern sea otter mortality investigations in 2012. California Department of Fish and Game, Office of Spill Prevention and Response Technical Report 13-1.

2011 Hatfield B.B., Ames J.A., Estes J.A., Tinker M.T., Johnson A.B., Staedler M.M., **Harris M.D**. Sea otter mortality in fish and shellfish traps: Estimating potential impacts and exploring possible solutions. Endangered Species Research. 13:219-229.

2010 Miller M.A., Conrad P.A., **Harris M.**, Hatfield B., Langlois G., Jessup D.A., Magargal S.L., Packham A.E., Toy-Choutka S., Melli A.C., Murray M.A., Gulland F.M., Grigg M.E. A protozoal-associated epizootic impacting marine wildlife: mass-mortality of southern sea otters (Enhydra lutris nereis) due to Sarcocystis neurona infection. Vet Parasitol. 172(3-4): 183-94.

2009 Miller M.A., Jang S., Byrne B., Dodd E., Dorfmeier E., **Harris M.**, Ames J., Paradies D., Worcester K., Jessup D.A., Miller W. Exposure to heavy freshwater runoff and dense coastal human populations are significant risk factors for enteric bacterial pathogen infection in California sea otters (Enhydra lutris nereis). Vet. Res. (2010) 41:01.

2008 Miller M.A., Miller W.A., Conrad P.A., James E.R.., Melli A.C., Leutenegger C.M., Dabritz H.A., Packham A.E., Paradies D**., Harris M.**, Ames J., Jessup D.A., Worcester K., Grigg M.E. Type X Toxoplasma gondii in a wild mussel and terrestrial carnivores from coastal California: New linkages between terrestrial mammals, runoff and toxoplasmosis of sea otters. Int. J. Parasitol. 38: 1319-28. COVER ARTICLE. MOST CITED MANUSCRIPT: 2008-2010.

2006 Miller, W.A., Miller M.A., Gardner I.A., Atwill E.R., Byrne B.A., Jang S., **Harris M**., Ames J., Jessup D., Paradies D., Worcester K., Melli A., Conrad P.A. Salmonella spp., Vibrio spp., Clostridium perfringens, and Plesiomonas shigelloides detected in freshwater and marine invertebrates from coastal California ecosystems. Microb. Ecol. 52(2): 198-206.

2005 Miller, W.A., Miller M.A., Gardner I.A., Atwill E.R., **Harris M.,** Ames J., Jessup D.A., Melli A.C., Paradies D., Worcester K., Olin P., Barnes N.M. Conrad P.A. New genotypes and factors associated with Cryptosporidium detection in mussels (Mytilus spp.) along the California coast. Int. J. Parasitol. 35:1103-1113.

2004 Jessup D.A., Miller M.A., Ames J.A., **Harris M**., Kreuder C., Conrad P.A., Mazet J.K. The southern sea otter (Enhydra lutris nereis) as a sentinel of marine ecosystem health. Ecol. and Health. 1:239-245.

2004 Olson M.E., Appelbee A., Measures L., Cole R.A., Lindsay D.S., Dubey J.P., Thomas N.J., Miller M.A., Conrad P.A., Gardner I.A., Kreuder C., Mazet J., Jessup D., Dodd E., **Harris M.**, Ames J., Worcester K., Paradies D., Grigg M., Fayer R., Lewis E.J., Trout J.M., Xiao L., Howard D.W., Palmer R., Ludwig K., Tyler S.S. Zoonotic protozoa in the marine environment: A threat to aquatic mammals & public health. Eds: R. Fayer, D. Lindsay. Vet. Parasitol. 125: 131–135.

2003 Kreuder C., Miller M.A., Jessup D.A., Lowenstine L.J., **Harris M.D,** Ames J.A., Carpenter T.E., Conrad P.A., Mazet J.K. Patterns of mortality in southern sea otters (Enhydra lutris nereis) from 1998–2001. J. Wildl. Dis. 39:495-509.

2002 Miller, M.A., Gardner I.A., Kreuder C., Paradies D.M., Worcester K.R., Jessup D., Dodd E**., Harris M.D.**, Ames J.A., Packham A.E., Conrad P.A. Coastal freshwater runoff is a risk factor for Toxoplasma gondii infection of southern sea otters (Enhydra lutris nereis). Int. J. Parasitol. 32:997-1006.

1997 Pattison, C. A., **Harris, M. D**., Wendell, F. E. Sea Otter, Enhydra lutris, mortalities in California, 1968 through 1993. California Department of Fish and Game Marine Resources Division, Marine Resources Division Administrative Report, 97-5

1996 Wendell, F., Pattison, C., and **Harris, M.** Sea otter, Enhydra lutris, containment management: field studies and feasibility assessment. California Department of Fish and Game Marine Resources Division, Marine Resources Division Administrative Report, 96-5.

Curriculum Vitae for Marissa Young
Monterey Bay Aquarium
886 Cannery Row
Monterey, CA 93940
(831) 647-6881

Objective:
The goal of the Registered Veterinary Technician position: to provide veterinary technician expertise to the living collection of animals, to manage the Animal Health Laboratory, to support MBA live animal research activities, and to undertake related husbandry program support activities.

Professional Employment:
August 2005-present — Monterey Bay Aquarium, Monterey, CA
Registered Veterinary Technician

- Perform Registered Veterinary Technician activities in support of a comprehensive veterinary medical program for the living animal collection. Perform monitoring for anesthetic procedures. Coordinate ordering of medical supplies and processing of diagnostic tests, manage pharmaceutical supplies, and maintain all relevant records and logs. Effect the maintenance of all veterinary medical and laboratory equipment; maintain, clean, and disinfect Animal Health Lab, Diagnostic Lab, and associated medical equipment. Work closely with veterinarian to detect medical problems, assist with veterinary procedures, and administer medical treatments. Perform routine laboratory testing using MBA facilities and equipment as directed by veterinarian. Take radiographs, maintain radiographic equipment and logs, and assure compliance with local, state, and federal regulations related to radiographic equipment and safety. Manage veterinary drugs and supplies to include ordering, inventory, accounting, and disposal. Coordinate training of staff and volunteers in veterinary medical support activities (e.g., injections, fluid therapy, surgical support, etc.). Provide professional veterinary technician support for in and ex situ research projects. Undertake all relevant data entry and record keeping for veterinary medical program. Maintain/manage serum/tissue bank of archived biological samples: coordinate archive; maintain records/database; work with veterinarian to deliver samples to researchers. Respond to stranded sea otter calls in the roll of a veterinary technician supporting the veterinarian. Interpret Animal Health Lab and Diagnostic Lab activities to the public. Undertake data entry and statistical analysis of data for the institution's veterinary program. Work independently and as an integral part of the veterinary program. Participate in planning for short- and long-term departmental goals. Interact and exchange information with colleagues. Participate in MBA public relations and educational activities, as needed. Participate in research projects or administrative tasks, as needed. Perform other MBA tasks, as needed
- 8/2005 to 9/2011: SORAC Animal Care Specialist: Provide medical and husbandry care for live-stranded sea otters, supervise and train volunteers in proper medical and husbandry practices for in-house animals. Clean and maintain sea otter holding tanks and SORAC food prep room. Participate in sea otter fieldwork including capture, release and tracking of animals, respond to dead and live animal strandings.

May 2004-August 2005 — Ocean View Veterinary Hospital, Pacific Grove, CA
Registered Veterinary Technician

- Responsible for cleaning cages, administering medical treatments and feeding in-house patients, surgical prep and assistance, anesthetic induction and monitoring, endotracheal intubation, phlebotomy, radiography, animal restraint, placement of intravenous catheters, dental prophylaxis and tooth extraction. Perform general laboratory work including urinalysis, fecal flotation, hematology, serum chemistry, and electrolyte analysis. Other duties include administration of vaccinations, client education, equipment maintenance, staff and volunteer training, computer data entry, and maintaining accurate animal medical records.

June 1999-May 2004 — Klaich Animal Hospital, Reno, NV
Registered Veterinary Technician

- Assist with general medical exams, animal restraint, administration of vaccinations, client education, anesthetic induction and monitoring, surgical prep and assistance, endotracheal intubation, phlebotomy, radiography, placement of intravenous catheters, dental prophylaxis, and administration of medications. Clean and maintain animal housing areas, oversee patient nutrition, equipment maintenance, perform laboratory diagnostics including hematology, serum chemistry, electrolyte analysis, and fecal flotation. Train staff, volunteers, and student interns, maintain proper animal medical records and an accurate controlled drug log.

Education:

Jan-Dec 2000	Community College of Southern Nevada, Las Vegas, NV Certificate of Achievement, Animal Health Technology
1997-1999	University of Nevada, Reno; Reno, NV Bachelor of Science in Ecology and Conservation Biology
1995-1997	Oregon State University, Corvallis, OR Undergraduate study

State Licensure:
Registered Veterinary Technician, State of California
September 2004-present
License Number: 6589

Registered Veterinary Technician, State of Nevada
March 2001-December 2004
License Number VT200

Professional Affiliations:
Association of Zoo Veterinary Technicians (AZVT)
California Registered Veterinary Technician Association (CaRVTA)
Association of Zoos and Aquariums (AZA)

Continuing Education:
Wild West Veterinary Conference, Reno, NV: 2000, 2001, 2002, 2004
Wildlife Veterinary Resources: Wildlife Handling and Chemical Immobilization for Veterinary Technicians; Forest Lake, MN October 2001
Western Veterinary Conference, Las Vegas, NV: February 2003, February 2015
Basic Wildlife Rehabilitation 1AB, International Wildlife Rehabilitation Council, San Luis Obispo, CA June 2003

Southern Sea Otter Symposium, Santa Cruz, CA 2005, 2006, 2007, 2009, 2010, 2012, 2014, 2016
Association of Zoo Veterinary Technicians Annual Conference, Toledo, OH September 2006
Oiled Wildlife Care Network, Basic Skills Training. Certificate of Completion, Cordelia, CA October 28-29, 2006
Reptilian and Amphibian Internal and External Parasitology, VSPN.org online course, Feb 15-March 10, 2007
Association of Zoo Veterinary Technicians Annual Conference, Honolulu, HI September 2007
Basic Fish Medicine, VSPN.org online course May 20-June 17, 2008
Association of Zoo Veterinary Technicians Annual Conference, New Bedford, MA October 2008
Association of Zoo Veterinary Technicians Annual Conference, Jackson Hole, WY October 2009
Association of Zoo Veterinary Technicians Regional Conference, Los Angeles, CA October 2010
Association of Zoo Veterinary Technicians Annual Conference, Tulsa, Oklahoma September 2016
Association of Zoo Veterinary Technicians Annual Conference, Columbus, OH August 2018
Diagnostic Cytology for Veterinary Practitioners, Abaxis University online webinar, February 8, 2011
Treating Blood Gas Dyscrasias, Abaxis University online webinar, April 19, 2011
Clinical Pathology for Reptiles, Abaxis University online webinar, January 25, 2012
Oiled Sea Otter Care Workshop, OWCN training seminar, February 10, 2012
UC Davis/SFSPCA Spring Veterinary Symposium, May 6, 2012
Reptile Hematology, VSPN.or online course; July 2012
Digital Radiology, Idexx Webinar series; September 2012
UC Davis Back-to-School RVT Seminar; July 2012, June 2013
Avian Hematology, VSPN.org online course; November 2015
Sea Otter Conservation Workshop, Seattle Aquarium, Seattle, WA March 2017

Presentations:
M. Young, Canine First Aid and Emergency Care. SARCON Western States Search & Rescue Training Conference, Reno/Stead, Nevada, April 22-25, 2004

M. Young, M. Murray, J. Coffey, SORAC Volunteer Medical Training Class, Monterey, CA August 2006, August 2009.

M. Young, Anesthetic Protocols and Monitoring in the Southern Sea Otter, AZVT 26th Annual Conference, Toledo, OH September 2006.

M. Young, Fracture Repair in a Southern Sea Otter, AZVT 26th Annual Conference, Toledo, OH September 2006.

M. Young, Stranding Response for Dependent-Aged Sea Otter Pups, CMMSN Confernce, San Diego, CA February 8-9, 2007.

M. Young, Monterey Bay Aquarium Animal Medical Procedures, People to People Conference, MBA Auditorium Program, Monterey, CA August 13, 2007.

M. Young, Stranding Response and Husbandry Care for Stranded Sea Otter Pups (*Enhydra lutris nereis*), AZVT 27th Annual Conference, Honolulu, HI September 2007.

M. Viens, Investing in Your Volunteers – A Training Program at the Monterey Bay Aquarium, AZVT 28th Annual Conference, New Bedford, MA October 2008.

M. Viens, Malignant Histiocyctic Sarcoma in a Female Southern Sea Otter (*Enhydra lutris nereis*), AZVT 28th Annual Conference, New Bedford, MA October 2008.

M. Viens, Experimental Treatment Protocol for Acanthocephalan Peritonitis in the Southern Sea Otter (*Enhydra lutra nereis*), AZVT 29th Annual Conference, Jackson Hole, WY 2009.

L. Tell, M. Young, What Otter You Waiting For? Long Acting Antibiotics for Sea Otters: Pharmacokinetics of Cefovecin. OWCN Oilapalooza Conference, San Diego, CA 2013.

M. Young, Preventive Health Program for Monitoring Monogenean Parasite Infections in Leopard Sharks (*Triakis semifasciata*) at Monterey Bay Aquarium. AZVT Annual Conference, Columbus, OH 2018.

M. Young, The Animal Care Center at Monterey Bay Aquarium: Justifying the Need for More Space. Poster presentation, AZVT Annual Conference, Columbus, OH 2018.

M. Young, Veterinary Care at the Monterey Bay Aquarium: The New Juli Plant Grainger Animal Care Center. Central Coast Registered Veterinary Technician Association meeting. February 2019.

Publications:

M. Young, Anesthetic Protocols and Monitoring in the Southern Sea Otter, AZVT 26th Annual Conference Proceedings, Toledo, OH September 2006.

M. Young, Fracture Repair in a Southern Sea Otter, AZVT 26th Annual Conference Proceedings, Toledo, OH September 2006.

M. Viens, Sea Otter Research and Conservation, *Veterinary Technician*, June 2008 Volume 29, No. 6

M. Viens, Investing in Your Volunteers – A Training Program at the Monterey Bay Aquarium, AZVT 28th Annual Conference Proceedings, New Bedford, MA October 2008.

M. Viens, Experimental Treatment Protocol for Acanthocephalan Peritonitis in the Southern Sea Otter (*Enhydra lutris nereis*). AZVT 29th Annual Conference Proceedings, Jackson Hole, WY September 2009.

Tyrrell, L. P., Newsome, S. D., Fogel, M. L., Viens, M., Bowden, R., & Murray, M. J. (2013). Vibrissae growth rates and trophic discrimination factors in captive southern sea otters (Enhydra lutris nereis). *Journal of Mammalogy,* 94(2), 331-338.

Lee, E. A., Byrne, B. A., Young, M. A., Murray, M. J., Miller, M. A., Tell, L. A. (2016). Pharmacokinetic indices for cefovecin after single-dose administration to adult sea otters (*Enhydra lutris)*. *Journal of Veterinary Pharmacology and Therapeutics*, 39(6), 625-628.

Volunteer Experience:

Sea Otter Research and Conservation program, Monterey Bay Aquarium, Monterey, CA August 2004-July 2005

- Clean and maintain animal holding tanks, prepare and feed animal diets, animal restraint, administration of medications, respond to animal stranding calls, computer data entry.

Animal Ark Wildlife Sanctuary, Reno, NV October 1999-May 2004

- Clean and maintain animal holding areas, prepare and feed animal diets for a variety of species, assist in the development and implementation of behavioral enrichment protocols, administer vaccinations, perform routine fecal exams on entire animal collection, act as park docent and school group tour leader, assist in the development of educational tours.

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Zachary Howland Randell

Education

Ph.D. Candidate, Integrative Biology, Oregon State University (Fall 2015 - anticipated graduation Spring 2020); Advisor: Dr. Mark Novak

- National Science Foundation Graduate Research Fellow (2016)
- Dr. Earl H. Myers & Ethel M. Myers Oceanographic & Marine Biology Trust Recipient (2019)

BS Biology, University of California Santa Cruz (2012)

- Senior honors thesis: "The effects of light, depth, and age on the distribution and abundance of extracellular polymeric substances found within a California *Macrocystis pyrifera* kelp bed."
- UCSC Diving control board undergraduate representative fall 2010 – fall 2012.

Work Experience

Biological Science Technician – Estes/Tinker Lab, UC Santa Cruz and the U.S. Geological Survey, Western Ecological Research Center, Santa Cruz field station (May 2012 – Sept. 2015)

- Responsible for coordinating sea otter tag tech development efforts between NASA engineers and USGS wildlife biologists (2014-present), with the objective of developing a sea otter flipper tag capable communicating geospatial data off via local networked communication.
- Daily execution of the Santa Barbara Channel (SBC) sea otter research project (May 2012 – April 2014). Responsible for capturing, tracking, and monitoring instrumented sea otters. Required boat and ground-based radio telemetry and visual surveillance.
- Sole resident who lived and maintained a remote field station.
- Participated in sea otter capture operations. Responsible for capturing, handling, transporting, and the release of wild sea otters for multiple long-term sea otter monitoring projects.

Subtidal Technician – Partnership for the Interdisciplinary Study of Coastal Oceans, UC Santa Cruz (June 2010 – Sept. 2011)

- Surveyed subtidal invertebrates and algae, and benthic, midwater, and canopy fishes (137 dives).
- Deployed, maintained, and retrieved oceanographic monitoring equipment.
- Assisted with SMURF (Standard Monitoring Unit for the Recruitment of Fishes) skin diving collection, fish identification, and fin clip sampling for genetic sampling.

Publications

- K. Grorud-Colvert, J. Sullivan, Z. Meunier, A. Rickborn, V. Constant, K. Dziedzic, B. Spiecker, **Z. Randell**, S. Hamilton, H. Fulton-Bennett, J. Lubchenco, S. Bachhuber. High-profile international commitments for ocean protection: Empty promises or meaningful progress? 2019. *Marine Policy*
- S. Gravem; S. Bachhuber; H. Fulton-Bennett; **Z. Randell**; A. Rickborn; J. Sullivan; B. Menge. 2017. Transformative Research Is Not Easily Predicted. *Trends in Ecology and Evolutionary Biology*
- T. Tinker; J. Tomoleoni; N. LaRoche; L. Bowen; **Z. Randell**. Southern Sea Otter Range Expansion and Habitat Use in the Santa Barbara Channel. 2015. Final Report to Bureau of Ocean and Energy Management

Professional Talks and Invited Presentations

- **Z. Randell**, *et al*. "Velocity of community shift and alternative states in southern California kelp forests. Oregon State University, Dept. of Integrative Biology, Spring Seminar invited speaker.
- **Z. Randell,** *et al*. **"**Velocity of community shift and alternative states: how long-term monitoring can focus dialogue surrounding nearshore conservation and management" Sea Otter Conservation Workshop, 2019.
- **Z. Randell**. "So you think sea otters are cute? An exclusive expose on the wily weasel of the waves" Biology Graduate Student Symposium, 2018

- **Z. Randell**; M. Kenner; T. Tinker. “Influence of habitat variation on 36 years of subtidal community structure at San Nicolas Island” Ecological Society of America, poster, 2017
- **Z. Randell**; M. Kenner; T. Tinker. “Influence of habitat variation on 35 years of subtidal community structure at San Nicolas Island” Seattle Aquarium Sea Otter Workshop, 2017
- **Z. Randell**; T. Tinker; M. Kenner. “Influence of habitat variation on 35 years of subtidal community structure at San Nicolas Island” California Island Symposium, 2016
- **Z. Randell**; T. Tinker; M. Staedler; M. Murray; L. Carswell; D. Jessup; B. McConnell. “OtterNet update: prototype microcontroller constructed and ready for Implantation” Southern Sea Otter Research Update Meeting (SSORUM), 2016
- **Z. Randell**; T. Tinker; M. Staedler; M. Murray; L. Carswell; D. Jessup; B. McConnell. “Advancing Tag Technology: A Peer-to-Peer Tracking Network for Wild Sea Otters” Society of Marine Mammology, poster, 2015
- **Z. Randell**; T. Tinker; M. Staedler; M. Murray; L. Carswell; D. Jessup; B. McConnell. “Advancing Tag Technology: A Peer-to-Peer Tracking Network for Wild Sea Otters” Sea Otter Conservation Workshop IX, 2015
- **Z. Randell**; T. Tinker; M. Staedler; M. Murray; L. Carswell; D. Jessup; B. McConnell. “Game Changer: Solar Powered Peer-to-Peer Tracking Network for Oiled and Rehabilitated Sea Otters” OWCN Research Symposium, 2015

Service

Within the Department of Integrative Biology during PhD (2015 – present)

- Organized special guest speaker Ken Collins (Microsoft) to give lecture on applying scientific skills towards opportunities in the private sector, 2017
- Biology Graduate Student Symposium committee: 2015, 2017, 2018
- Graduate representative on *ad hoc* Cordley Remodel Committee, 2018
- Graduate representative on *ad hoc* Graduate Curriculum Review Committee, 2019

Community Outreach and Education

- Participated in Science Math Investigative Learning Experiences (SMILE) in 2018
- Helped organize and gave lecture at Integrative Biology Open House 2017 and 2018
- Guest lecturer at Marine Ecology (May 2017) and Marine Biology (March 2018) undergraduate classes at Oregon State
- Guest lecturer for a Marine Conservation undergraduate class at Pacific University (Jan 2017)
- Trained Santa Barbara Zoo volunteers in field protocols to survey and collect wild sea otter data
- Trained CIMWI volunteers in basic animal husbandry
- Organized sea otter and ocean awareness week outreach events at the Santa Barbara Zoo
- Lectured at local K-12 schools on local factors imperiling sea otter recovery

Field Experience

SCUBA certifications and experience

- 504 scientific dives, roughly 75 recreational dives
- 100% O2 rebreather certified for sea otter capture diving operations
- Scientific Certified (100 FSW): UC Santa Cruz 20 Jun 2010, Rescue: UCSC: 3 Oct 2008
- Dry Suit, Rescue, Nitrox, and Open water certified (PADI) Seward, AK: 2005 - 2007

Small boat operator

- 289 separate days operating inflatables, Boston Whalers, Andersons, and Radons (8-25’).
- Motorboat Operator Training Certification (MOTC) Spring 2011, UCSC
- Checked out as primary operator: R/V Terrace Pt., Lucy M., Sebastes, Whitecap, Pursuit.
- Primary operator for UCSC and USGS projects in near shore and open-ocean conditions including skin, SCUBA, and rebreather diver deployment and retrieval.
- Boat trailering, maintenance, and repair – electrical, fiberglass, painting, trailer body, etc.

CURRICULUM VITAE

James L. Bodkin

Scientist Emeritus
Alaska Science Center
Retired
[redacted]
[redacted] cell

Current Position: Consultant, James L. Bodkin Biological Consulting

Prior responsibilities: Coastal Systems Project Leader. Responsible for the design and implementation of coastal marine research for the Alaska Science Center. Responsibilities include preparation and approval of study plans, supervision of research projects and preparation of results, and publication of results. Responsible for managing coastal systems project staff. Directs coastal systems research annual funding allocations. Southern Alaska Coastal Ecosystem Team Leader.

Previous Positions: Wildlife Biologist (Research) GS-486-14. Alaska Science Center. U.S. Geological Survey. Anchorage, Alaska. December 2006-November 2012

Wildlife Biologist (Research) GS-486-13. Alaska Biological Science Center. U.S. Geological Survey. Anchorage, Alaska. August 1996-2006.

Wildlife Biologist (Research) GS-486-12. Alaska Biological Science Center. U.S. Geological Survey. Anchorage, Alaska. August 1990-1996.

Wildlife Biologist GS-486-11, Koyukuk/Nowitna National Wildlife Refuge. U.S. Fish and Wildlife Service. Galena Alaska. 1989-1990.

Fish & Wildlife Biologist GS-401-11, National Ecology Research Center, U.S. Fish and Wildlife Service. Santa Cruz field station. 1986-1989

Biological Technician (Wildlife) GS-404-09, National Ecology Research Center, U.S. Fish and Wildlife Service, San Simeon field station. 1980-1986

Biological Technician (Fisheries) GS-404-05, National Marine Fisheries Service, Southwest Fisheries Center, La Jolla, California, 1977-1980

Education: 1985 -MS, California Polytechnic State University, San Luis Obispo, CA. (Wildlife Biology)
1976- BS, Long Beach State University (Biology), Long Beach, CA
1972 - AS, Cypress College (Biology), Cypress, CA

Other Training: 1989 - Arctic Survival Course, US Air Force, Eilson AFB, AK.
1989 - Fire Management Training, USFWS, Kenai, Alaska.
1977-Certified Radio Telephone Operator, third class, Department of Commerce.
1975 -Research Diving Certification, Advanced Professional Association of Diving Instructors (PADI)
1970 -Basic Scuba Certification, National Association of Scuba Diving Schools (NASDS), Research Diving Certification
Current certificates in CPR, Oxygen administration and First-aid.

Memberships: Society for Marine Mammalogy
American Society of Mammalogists
Society for Conservation Biology
Wildlife Society
Western Society of Naturalists
National Geographic Society

Science Advisory Committee, Glacier Bay National Park
Alaska Sea Otter Commission, Scientific Advisor
USGS National Diving Control Board Member

State and Federal Collecting Permits
Federal Marine Mammal/OMA Permits; PRT 750916 PRT 672624, PRT 710118, PRT 684532, PRT 692350

State Permits; Alaska State Permit 90-69

Publications

Bodkin, J.L. 1984. A comparison of fish assemblages in Macrocystis and Nereocystis kelp forests off central California. MS Thesis. California Polytechnic State University, San Luis Obispo. 98 pp.

Bodkin, J.L., R.J. Jameson and G.R. VanBlaricom. 1985. Pup production, abundance, and breeding distribution of northern elephant seals on San Nicolas Island, Winter 1981. Calif. Fish and Game. 71(1):53-59.

VanBlaricom, G.R., D.C. Reed, C. Harrold and J.L. Bodkin. 1985. A sublittoral population of Pleurophycyus gardneri Setchell and Saunders 1900 (Phaeophyceae: Laminariaceae) in central California. Bull. Southern California Acad. Sci. 84(3).

Bodkin, J.L. 1986. Fish assemblages in Macrocystis and Nereocystis kelp forests off central California. U.S. Fishery Bulletin. 84(4):799-808.

Jameson, R.J. and J.L. Bodkin. 1986. An incidence of twinning in the sea otter (Enhydra lutris). Marine Mammal Science. 2(4):304-309.

Bodkin, J.L., G.R. VanBlaricom and R.J. Jameson. 1987. Mass mortalities of nearshore fishes following period of large, long period storm swells. Environmental Biology of Fishes. 18(1):73-76.

Bodkin, J.L. 1988. Effects of kelp forest removal on associated fish assemblages in central California. Journal of Experimental Marine Biology and Ecology. 117:227-238.

Bodkin, J.L. and F. Weltz. 1990. A summary and evaluation of sea otter rescue operations in response to the Exxon Valdez oil spill, Prince William Sound, Alaska, 1989. Proceedings; Sea Otter Symposium, Anchorage, Alaska, 17-19 April, 1990. pp 61-69.

Bodkin, J.L. and R. Jameson. 1991. Patterns of seabird and marine mammal carcass deposition along the central California coast, 1980-1986. Can J. Zool. 69:1149-1155.

Bodkin, J.L. and L. Browne. 1992. Molt frequency and size-class distribution in the spiny lobster (Panulirus interruptus), at San Nicolas Island, California. California Fish and Game. 78(4):136-144.

Bodkin, J. L., B.E. Ballachey and M. Cronin. 1992. Mitochondrial DNA and the conservation and management of sea otters. Research Information Bulletin No. 37. US Fish and Wildlife Service, Office of Information Transfer.

Bodkin, J. L., D. Mulchay and C.J. Lensink. 1993. Age specific reproduction in the sea otter *(Enhydra lutris)*; an analysis of reproductive tracts. Can. J. Zool. 71(9): 1811-1815.

Cowen, R.K. and J.L. Bodkin. 1993. Annual and spatial variation of the kelp forest fish assemblage at San Nicolas Island, California. Pp 464-474. *In*, F.G. Hochberg (ed.) Third California Islands Symposium: recent advances in research on the California Islands. Santa Barbara Museum of Natural History, Santa Barbara, CA.

Udevitz, M.S., J.L. Bodkin and D.P. Costa. 1995. Sea otter detectability in boat-based surveys of Prince William Sound, Alaska. Marine Mammal Science. 11(1) :59-71.

Ballachey, B.E., J.L. Bodkin and A.R. DeGange. 1994. An overview of sea otter studies. *in* T. Loughlin editor. Marine mammals and the Exxon Valdez. Academic Press. San Diego, CA pages 47-59.

Bodkin, J.L. and M.S. Udevitz. 1994. Intersection model for estimating sea otter mortality along the Kenai Peninsula. *in* T. Loughlin editor. Marine mammals and the Exxon Valdez. Academic Press. San Diego, CA pages 81-95.

Doroff, A.M. and J.L. Bodkin. 1994. Sea otter foraging behavior and hydrocarbon levels in prey. *in* T. Loughlin, editor. Marine mammals and the Exxon Valdez. Academic Press. San Diego, CA pages 193-208.

Cronin, M.A., J.L. Bodkin, B.E. Ballachey, J.A. Estes, and J.C. Patton. 1996. Mitochondrial DNA variation among subspecies and populations of sea otters (Enhydra lutris). J. Mammalogy. 77(2):547-557.

Bodkin, J.L., R.J. Jameson and J,A, Estes. 1994. Sea otters in the North Pacific Ocean. *In* E.T. LaRoe III, G.S. Farris, C.E. Puckett and P.D. Doran, editors. *Our Living Resources 1994: A report to the nation on the distribution, abundance and health of U.S. plants, animals and ecosystems.* National Biological Service. Washington D.C. pages 353-356.

J.A. Estes, R.J. Jameson, J.L. Bodkin and D.R. Carlson. 1994. Status and trends of the California sea otter population. *In* E.T. LaRoe III, G.S. Farris, C.E. Puckett and P.D. Doran, editors. *Our Living Resources 1994: A report to the nation on the distribution, abundance and health of U.S. plants, animals and ecosystems.* National Biological Service. Washington D.C. pages110-112.

Bodkin, J.L., J.A. Ames, R.J. Jameson, A.M. Johnson and G.M. Matson. 1997. Accuracy and precision in estimating age of sea otters using cementum layers in the first premolar. J. Wildlife Management 61(3):967-973.

Bodkin, J.L. and B.E. Ballachey. 1996. Monitoring the status of the wild sea otter population: field studies and techniques. Endangered Species Update. University of Michigan Vol 13(12):14-20.

Estes, J.A., D.F. Doak, J.L. Bodkin, R.J. Jameson, D. Monson, J, Watt and T. Tinker. 1996. Comparative demography of sea otter populations. Endangered Species Update. University of Michigan Vol.13(12):11-13.

Shirley, T.C., C.E. O'Clair, S.J. Taggart, and J.L. Bodkin. 1996. Sea otter predation on Dungeness crabs in Glacier Bay, Alaska. Pgs. 563-576 in: International Symposium on Biology, Management, and Economics of Crabs from High Latitude Habitats. Alaska Sea Grant College Program, Anchorage, Alaska.

Scribner, K.T., J.L. Bodkin, B.E. Ballachey, S.R. Fain, M.A. Cronin and M. Sanchez. 1997. Population and genetic studies of sea otter (*Enhydra lutris*): A review and interpretation of available data. Pages 197-208 *in* A.E. Dizon, S.J. Chivers, and W.F. Perrin, eds. Molecular genetics of marine mammals. Special Publication 3 by the Society for Marine Mammalogy. Allen Press.

Bodkin, J.L. and B.E. Ballachey. 1997. Restoration Notebook Series: Sea Otter (*Enhydra lutris)* Exxon Valdez Oil Spill Trustee Council. Anchorage, AK.

Bodkin, J.L., B.E. Ballachey, M.A. Cronin and K.T. Scribner. 1999. Population demographics and genetic diversity in remnant and re-established populations of sea otters. Conservation Biology 13(6):1278-1385.

Bodkin, J. L. and M.S. Udevitz. 1999. An aerial survey method to estimate sea otter abundance. in: Garner, G.W., S.C. Amstrup, J.L. Laake, B.F.J. Manly, L.L. McDonald, and D.G. Robertson, (eds.) Marine mammal survey and assessment methods. Balkema Press, Netherlands pg. 13-26.

Bodkin, J.L., A.M. Burdin and D.A. Ryzanov. 2000. Age and sex specific mortality and population structure in sea otters. Marine Mammal Science 16(1):201-219.

Monson, D.H., J.A. Estes, J.L. Bodkin and D.B. Siniff. 2000. Life history plasticity and population regulation in sea otters. Oikos. 90:3 457-468.

Adkison, M.D., B. Ballachey, J. Bodkin, and L. Holland-Bartels. 1998. Integrating ecosystem studies: a Bayesian comparison of hypotheses. In: F. Funk, J.N. Ianelli, T.J. Quinn II, and P.J. Sullivan (eds.) Proceedings of the international symposium on fishery stock assessment models for the 21st century. Alaska Sea Grant College Program.

Dean, T.A., J.L. Bodkin, S.C. Jewett, D.H. Monson and D. Jung. 2000. Changes in sea urchins and kelp following a reduction in sea otter density as a result of the *Exxon Valdez* oil spill. Marine Ecology Progress Series. 199:281-291.

Bodkin, J.L. 2000. Sea otters past and present perspectives. Alaska Geographic. 7(2):73-93.

Monson, D.H., D.F. Doak, B.E. Ballachey, A. Johnson, and J.L. Bodkin. 2000. Long-term impacts of the *Exxon Valdez* oil spill on sea otters, assessed through age-dependent mortality patterns. Proceedings National Academy of Sciences, USA.97(12):6562-6567.

Bodkin, J.L. 2001. Marine Mammals: Sea otters. Pages 2614-2621. in Steele, J. S.Thorpe and K. Turekian (eds.) Encyclopedia of Ocean Sciences. Academic Press, London UK. (invited ms)

Gorbics, C and J.L. Bodkin. 2001. Stock Identity of sea otters in Alaska. Marine Mammal Science 17(3):632-647.

Dean, T.A., J.L. Bodkin, A.K. Fukuyama, S.C. Jewett, D.H. Monson, C.E. O'Clair, and G.R. VanBlaricom. 2002. Food limitation and the recovery of sea otters in Prince William Sound. Marine Ecology Progress Series. 241:255-270.

Bodkin, J.L., B.E. Ballachey, T.A. Dean, A.K. Fukuyama, S.C. Jewett, L.M. McDonald, D.H.Monson, C.E. O'Clair and G.R. VanBlaricom. 2002. Sea otter population status and the process of recovery from the Exxon Valdez oil spill. Marine Ecology Progress Series. 241:237-253.

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Bodkin, J.L. and D.H. Monson. 2002. Sea otter population structure and ecology in Alaska. Arctic Research. 16:31-35

Baskaran, M., G.-H. Hong, S. Dayton, J.L. Bodkin, and J.J. Kelly. 2003. Temporal variations of natural and anthropogenic radionuclides in sea otter skull tissue in the North Pacific Ocean. J. Env. Radioactivity 64:1-18.

Bodkin, J.L. 2003. Return to Glacier Bay. Alaska Park Science, National Park Service, Anchorage, AK pages 4-11

Peterson, C.H., S.D. Rice, J.W. Short, D. Esler, J.L. Bodkin, B.E. Ballachey, D.B. Irons. 2003. Long-term ecosystem response to the Exxon Valdez oil spill. Science 302:2082-2086.

Ballachey, B.E., J.L. Bodkin, S. Howlin, A.M. Doroff, and A.H. Rebar. 2003. Correlates to survival of juvenile sea otters in Prince William Sound, Alaska. Canadian J. Zoology 81:1494-1510.

Bodkin, J.L. 2003. Sea Otter. Pages 735-743, in Feldham. G. A., B.C. Thompson, and J.A. Chapman (eds), Wild Mammals of North America, 2nd edition. Johns Hopkins University Press, Baltimore. 735-743. (invited ms).

Bodkin, J.L., G.G. Esslinger and D.H. Monson. 2004. Foraging depths of sea otters and implications to coastal marine communities. Marine Mammal Science 20(2):305-321.

Bodkin, J.L. 2004. Status of sea otter populations in south central and southeast Alaska, 2002-2003. Pages 12-13 *in* D. Maldini, D. Calkins, S. Atkinson, and R. Meehan, eds. Alaska Sea Otter Workshop: Addressing the decline of the southwestern Alaska sea otter population. Alaska Sea Grant College Program, University of Alaska, Fairbanks, AK, pp 12-13.

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Monson, D.H., J.L. Bodkin, D.F. Doak, J.A. Estes, M.T. Tinker, and D.B. Siniff. 2004. Population demographics, survival, and reproduction: Alaska sea otter research. Pages 60-65 *in* D. Maldini, D. Calkins, S. Atkinson, and R. Meehan, eds. Alaska Sea Otter Workshop: Addressing the decline of the southwestern Alaska sea otter population. Alaska Sea Grant College Program, University of Alaska, Fairbanks, AK

Lowry, L.L. and J.L. Bodkin. 2005. Marine Mammals, in. Phillip R. Mundy (ed.). The Gulf of Alaska: Biology and Oceanography. Alaska Sea Grant College Program, University of Alaska Fairbanks. pp 99-116

Scribner, K.T. B.A. Green, C. Gorbics, and J.L. Bodkin. 2005. Verification of field-reported sex from harvested sea otters using DNA testing. Wildlife Society Bulletin 33(3):1-6.

Laidre, K.L., J. A. Estes, M. T. Tinker, J. Bodkin, D. Monson, and K. Schneider. 2006. Patterns of growth and body condition in sea otters from the Aleutian archipelago before and after the recent population decline. J. Animal Ecology 75:978-989.

Tinker, T.M., D.F. Doak, J.A. Estes, B.H. Hatfield, M.M. Staedler, J.L. Bodkin. 2006. Incorporating diverse data and realistic complexity into demographic estimation procedures: a case study using the California sea otter, *Enhydra lutris nereis*. Ecological Applications 16(6):2293-2312.

Iverson, S.J., A.M. Springer, and J.L. Bodkin 2007. Strategies for survival: Marine Mammals. Pages 114-131, *in* Robert Spies (ed.). Long term ecosystem change in the northern Gulf of Alaska. Elsevier, Amsterdam, the Netherlands.

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Bodkin, J.L., Ballachey, B.E., Esslinger, G.G., Kloecker, K.A., Monson, D.H., and Coletti, H.A., 2007, Perspectives on an invading predator—Sea otters in Glacier Bay, *in* Piatt, J.F., and Gende, S.M., eds., Proceedings of the Fourth Glacier Bay Science Symposium, October 26–28, 2004: U.S.Geological Survey Scientific Investigations Report 2007-5047, p. 133-136.

Romano, M.D., J.F. Piatt, G.S. Drew, and J.l. Bodkin 2007 Temporal and spatial variability in distribution of Kittliitz's murrellet in Glacier Bay, *in* Piatt, J.F., and Gende, S.M.., eds., Proceedings of the Fourth Glacier Bay Science Symposium, October 26–28, 2004: U.S.Geological Survey Scientific Investigations Report 2007-5047, p. 117-119.

Drew, G.S., J.F. Piatt, and J.L. Bodkin. 2007. Population status and trends of marine birds and mammals in Glacier bay National Park and Preserve, *in* Piatt, J.F., and Gende, S.M., eds., Proceedings of the Fourth Glacier Bay Science Symposium, October 26–28, 2004: U.S.Geological Survey Scientific Investigations Report 2007-5047, p. 129-132.

Bodkin, J.L.. and Boudreau, S.L, 2007, Toward an integrated science plan for Glacier Bay National Park and Preserve: Results from a Workshop, 2004, in Piatt, J.F., and Gende, S.M., eds., Proceedings of the Fourth Glacier Bay Science Symposium, October 26–28, 2004: U.S. Geological Survey Scientific Investigations Report 2007-5047, p. 217-218.

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Estes, J.A., J.L. Bodkin, and M Ben-David. 2008. Marine Otters. In W.F. Perrin, B. Wursig,, J.G.M. Thewissen and C.R. Crumly (eds) Encyclopedia of Marine Mammals, 2nd Edition. Academic Press. (invited ms).

Drew, G.S., S.G. Speckman, J.F. Piatt, J.M. Burgos, and J.L Bodkin. 2008. Survey Design Considerations for Monitoring Marine Predator Populations in Glacier Bay, Alaska: Results and Post-hoc Analyses of Surveys Conducted in 1999-2003. US Geological Survey, Administrative Report, Alaska Science Center, Anchorage, AK, 126pp.

G.G.Esslinger and J.L. Bodkin. 2009. Trends in Southeast Alaska sea otter populations; 1969-2003. USGS Scientific Investigations 2009–5045 18pp.

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Bodkin, J.L., T.A. Dean, and H.A. Coletti. 2007. SWAN Nearshore Monitoring: Testing and Trial Implementation, Katmai NP, 2006. National Park Service, SWAN annual investigators meeting. 6-7 March, 2007, Homer, AK.

Bodkin, J.L**.** Rapid expansion of sea otters in Glacier Bay. 2006. Indigenous People's Council for Marine Mammals. Board of Directors Meeting. 30 October, 2006. Invited presentation.

Bodkin, J.L. B.E. Ballachey, and D.H. Monson. 2006. Persistence of spilled oil in nearshore sediments and pathways of exposure to foraging sea otters. Carnivores 2006, 11-15 Nov. 2006, St. Petersburg, FL. Invited presentation

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Pacific Marine Research Institute and Pollock Conservation Cooperative Studies. 13-17 January, 2003, Anchorage, Alaska.

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Research Wildlife Biologist, Alaska Science Center, 1996-present
Biological Technician and Statistical Assistant, Alaska Science Center, 1987-1996
2009 – Ph.D., University of California Santa Cruz, Santa Cruz, CA. (Ecol. & Evol. Biology)
1995 – M.S., University of California Santa Cruz, Santa Cruz, CA. (Marine Science)
1983 – B.A., Luther College, Decorah, Iowa (Biology)

I have worked within the Coastal Ecosystems research program for the Alaska Science Center since 1987 where I have three decades of experience conducting multi-disciplinary research on sea otters and their nearshore environment with collaborators from more than a dozen different agencies, academic and private institutions. I have focused on developing metrics of sea otter population status, which can provide important insights into the health and function of nearshore systems. Beginning in 2012, I became a PI for the Nearshore component within the GulfWatch Program where my role is to conduct high quality research focused on understanding natural and anthropogenic factors affecting nearshore ecosystems that will be critical for ecosystem-based management of these resources.

Relevant Publications

Chinn, S. M., D. H. Monson, M.T. Tinker, M. M. Staedler, and D. E. Crocker. 2018. Lactation and Resource Limitation Affect Stress Responses, Thyroid Hormones, Immune Function and Antioxidant Capacity of Sea Otters (*Enhydra lutris*). Integrative and Comparative Biology. 58:E37.

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Laidre, K.L., J.A. Estes, M.T. Tinker, J. Bodkin, D. Monson, and K. Schneider. 2006. Patterns of growth and body condition in sea otters from the Aleutian archipelago before and after the recent population decline. J. of Animal Ecol. 75:978–989.

Bodkin, J.L., G.G. Esslinger, and D.H. Monson. 2004. Foraging depths of sea otters and implications to coastal marine communities. Mar. Mamm. Sci. 20:305-321.

Bodkin, J.L., B.E. Ballachey, T.A. Dean, A.K. Fukuyama, S.C. Jewett, L. McDonald, D.H. Monson, C.E. O'Clair, and G.R. VanBlaricom. 2002. Sea otter population status and the process of recovery from the 1989 'Exxon Valdez' oil spill. Marine Ecology Progress 241:237-253.

Dean, T.A., J.L. Bodkin, A.K. Fukuyama, S.C. Jewett, D.H. Monson, C.E. O'Clair, and G.R. VanBlaricom. 2002. Food limitation and the recovery of sea otters following the 'Exxon Valdez' oil spill. Marine Ecology Progress Series. 241:255-270.

Monson, D.H., C. McCormick, and B.E. Ballachey. 2001. Chemical anesthesia of northern sea otters (*Enhydra lutris*): Results of past field studies. J. Zoo Wildl. Medicine 32:181-189.

Monson, D.H., D.F. Doak, B.E. Ballachey, A. Johnson, and J.L. Bodkin. 2000. Long-term impacts of the *Exxon Valdez* oil spill on sea otters, assessed through age-dependent mortality patterns. Proceedings of the National Academy of Sciences. 97:6562-6567.

Monson, D.H., J. A. Estes, J.L. Bodkin, and D.B. Siniff. 2000. Life history plasticity and population regulation in sea otters. Oikos 90:457-468.

Dean, T.A., J.L. Bodkin, S.C. Jewett, D.H. Monson, and D. Jung. 2000. Changes in sea urchins and kelp following a reduction in sea otter density as a result of the *Exxon Valdez* oil spill. Marine Ecology Progress Series 199:281-291.

Monson, D.H., and A.R. DeGange. 1995. Reproduction, preweaning survival, and survival of adult sea otters at Kodiak Island, Alaska. Can. J. Zool 73:1161-1169.

DeGange, A.R., A.M. Doroff, and D.H. Monson. 1994. Experimental recovery of sea otter carcasses at Kodiak Island, Alaska, following the *Exxon Valdez* oil spill. Mar. Mamm. Sci. 10:492-496.

CURRICULUM VITAE
7 May 2019

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Education

2011 - Master of Science, Biological Sciences, University of Alaska, Anchorage, AK
1993 - Bachelor of Science, Wildlife, Humboldt State University, Arcata, CA

Work experience

11/98 – present	Zoologist, U.S. Geological Survey, Anchorage, AK
10/96 – 11/98	Fish and Wildlife Biologist, U.S. Geological Survey, Anchorage, AK
04/95 – 10/96	Fish and Wildlife Biologist, U.S. Fish and Wildlife Service, Anchorage, AK
04/93 – 04/95	Biological Science Technician, U.S. Fish and Wildlife Service, Anchorage, AK

Professional licenses and memberships

Member, USGS Diving Safety Board, 2010-present, Anchorage, AK
Research Vessel Manager, U.S. Geological Survey, 2006-present, Anchorage, AK
Oxygen Rebreather Diver, Aqua Lung, 2006, Vista, CA
Master 50-100 ton License, U.S. Coast Guard, 1999-present, Anchorage, AK
Motorboat Operator Instructor, Department of Interior, 1997, Lake Mead, NV
Divemaster, NOAA Dive Program, 1996, Seattle, WA
Working Diver, NOAA Dive Program, 1994, Seattle, WA

Publications

Tinker, MT, V Gill, GG Esslinger, JL Bodkin, M Monk, M Mangel, DH Monson, WW Raymond, M Kissling. In Press. Trends and carrying capacity of sea otters in southeast Alaska. Journal of Wildlife Management.

Williams, PJ, MB Hooten, GG Esslinger, JN Womble, JL Bodkin, and MR Bower. 2019. The rise of an apex predator following deglaciation. Diversity and Distributions 25.

Esler, D., B.E. Ballachey, C. Matkin, D. Cushing, R. Kaler, J. Bodkin, D. Monson, G. Esslinger, and K. Kloecker. 2018. Timelines and mechanisms of wildlife population recovery following the Exxon Valdez oil spill. Deep-Sea Research Part II 147:36-42.

Williams, PJ, MB Hooten, JN Womble, GG Esslinger, and MR Bower. 2018. Monitoring dynamic spatio-temporal ecological processes optimally. Ecology 99:524-535.

Williams, PJ, MB Hooten, JN Womble, GG Esslinger, M Bower, & TJ Hefley. 2017. An integrated data model to estimate spatio-temporal occupancy, abundance, and colonization dynamics. Ecology 98:328–336.

Esslinger, G.G., D. Esler, S. Howlin, and L.A. Starcevich. 2015. Monitoring population status of sea otters (*Enhydra lutris*) in Glacier Bay National Park and Preserve, Alaska—Options and considerations. U.S. Geological Survey Open-File Report 2015-1119, 42 p., http://dx.doi.org/10.3133/ofr20151119.

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Bodkin, J.L., B.E. Ballachey, H.A. Coletti, G.G. Esslinger, K.A. Kloecker, S.D. Rice, J.A. Reed, and D.H. Monson. 2012. Long-term effects of the Exxon Valdez oil spill: Sea otter foraging in the intertidal as a pathway of exposure to lingering oil. Marine Ecology Progress Series 447:273-287.

Bodkin, J.L., B.E. Ballachey, and G.G. Esslinger. 2011. Trends in sea otter population abundance in western Prince William Sound, Alaska: Progress toward recovery following the 1989 *Exxon Valdez* oil spill. U.S. Geological Survey Scientific Investigations Report 2011–5182, 14 p.

Esslinger, G. G. 2011. Temporal patterns in the behavior and body temperature of sea otters in Alaska. M.S. Thesis, Department of Biological Sciences, University of Alaska, Anchorage. 74 pp.

Jewett, S. C., J. L. Bodkin, H. Chenelot, G. G. Esslinger, and M. K. Hoberg. 2010. The Nearshore Benthic Community of Kasatochi Island, One Year after the 2008 Volcanic Eruption. Arctic, Antarctic, and Alpine Research 42(3):315-324. DOI:10.1657/1938-4246-42.3.315

Esslinger, G.G., and J.L. Bodkin. 2009. Status and Trends of Sea Otter Populations in Southeast Alaska, 1969-2003. U.S. Geological Survey Scientific Investigations Report 2009–5045, 19 p.

Bodkin, J. L., D. H. Monson, and G. G. Esslinger. 2007. Activity budgets derived from time-depth recorders in a diving mammal. Journal of Wildlife Management 71(6):2034-2044.

Bodkin, J. L., B. E. Ballachey, G. G. Esslinger, K. A. Kloecker, D. H. Monson, and H. A. Coletti. 2007. Perspectives on an invading predator, Sea otters in Glacier Bay. Pages 133-136 *in* J. F. Piatt and S. M. Gende, eds., Proceedings of the Fourth Glacier Bay Science Symposium, 2004, October 26-28, 2004: U.S. Geological Survey Scientific Investigations Report, Anchorage, AK.

Bodkin, J. L., G. G. Esslinger, and D. H. Monson. 2004. Foraging depths of sea otters and implications to coastal marine communities. Marine Mammal Science 20(2):305-321.

Reports

Garlich-Miller, J, GG Esslinger, BP Weitzman. 2018. Aerial surveys of sea otters (*Enhydra lutris*) in lower Cook Inlet. U.S. Fish and Wildlife Service Report, Anchorage, AK.

Weitzman, BP, and GG Esslinger. 2015. Aerial sea otter abundance surveys—Prince William Sound, Alaska, Summer 2014. Administrative Report, U.S. Geological Survey, Anchorage, AK.

Esslinger, GG, JL Bodkin, and BP Weitzman. 2013. Sea otter population abundance, distribution, and growth in Glacier Bay, Southeast Alaska. Administrative Report, U.S. Geological Survey, Anchorage, AK.

Coletti, H. A., J. L. Bodkin, and G. G. Esslinger. 2011. Distribution and density of marine birds and mammals along the Kenai Fjords National Park coastline - March 2010. Natural Resource Technical Report NPS/SWAN/NRTR—2011/451. National Park Service, Fort Collins, Colorado.

Bodkin, J.L., G.G. Esslinger, and B.E. Ballachey. 2010. Trends in sea otter population abundance in western Prince William Sound: Progress toward recovery following the 1989 "Exxon Valdez oil spill. Exxon Valdez Restoration Project //0808. Draft Final Report. *Exxon Valdez* Restoration Office, Anchorage, AK. 112 pp.

Coletti, H. A., J. L. Bodkin, and G. G. Esslinger. 2010. Sea otter abundance in Kenai Fjords national Park: results from the 2010 aerial survey: Southwest Alaska Inventory and Monitoring. Natural Resource Technical Report NPS/SWAN/NRTR—2010/XXX. National Park Service, Fort Collins, Colorado.

Bodkin, J. L., B. E. Ballachey, K. A. Kloecker, G. G. Esslinger, D. H. Monson, H. A. Coletti, and J. A. Estes. 2004. Sea otter studies in Glacier Bay National Park and Preserve. Annual Report 2003. USGS Alaska Science Center, Anchorage, AK.

Bodkin, J. L., B. E. Ballachey, G. G. Esslinger, K. A. Kloecker, , D. H. Monson, H. A. Coletti, and J. Doherty. 2003. Sea otter studies in Glacier Bay National Park and Preserve. Annual Report 2002. USGS Alaska Science Center, Anchorage, AK.

Bodkin, J. L., B. E. Ballachey, K. A. Kloecker, G. G. Esslinger, D. H. Monson, H. A. Coletti, and J. Doherty. 2003. Sea otter studies in Glacier Bay National Park and Preserve. Annual Report 2002. USGS Alaska Science Center, Anchorage, AK.

Bodkin, J. L., D. H. Monson, and G. G. Esslinger. 2003. Results of the 2002 Kenai Peninsula and Lower Cook Inlet Aerial Sea Otter Survey. U.S. Geological Survey, Anchorage, AK.

Bodkin, J. L., K. A. Kloecker, H. A. Coletti, G. G. Esslinger, D. H. Monson, and B. E. Ballachey. 2002. Marine predator surveys in Glacier Bay National Park and Preserve. Annual Report 2001. USGS Alaska Science Center, Anchorage, AK.

Bodkin, JL, KA Kloecker, GG Esslinger, DH Monson, JD DeGroot, and J Doherty. 2002. Sea otter studies in Glacier Bay National Park and Preserve. Annual Report 2001. USGS Alaska Science Center, Anchorage, AK.

Bodkin, JL, GG Esslinger, and DH Monson. 2002. Estimated sea otter population size in Glacier Bay, May 1999. USGS Alaska Biological Science Center, Anchorage, AK.

Bodkin, JL, KA Kloecker, GG Esslinger, DH Monson, JD DeGroot. 2001. Sea otter studies in Glacier Bay National Park and Preserve. Annual Report 2000. USGS Alaska Biological Science Center, Anchorage, AK.

Presentations

Esslinger, GG. 2018. A sea otter aerial survey method that adjusts for detection. 2018 Sea Otter Survey Meeting – New Ideas, New Directions, Santa Cruz, CA, 21 March 2018.

Esslinger, GG, D Esler, KA Kloecker, DH Monson, B Robinson, BP Weitzman. 2018. Current research on sea otters in Alaska by the Nearshore Marine Ecosystem Research Program. Southern Sea Otter Research Update Meeting, Santa Cruz, CA, 20 March 2018.

Esslinger, GG. 2017. A sea otter aerial survey method that adjusts for detection. Sea otter population monitoring in Alaska – An Inter-agency Meeting, Anchorage, AK, 8-9 November 2017.

Esslinger, GG. 2017. Sea otter survey efforts and priorities for the U.S. Geological Survey. Sea otter population monitoring in Alaska – An Inter-agency Meeting, Anchorage, AK, 8-9 November 2017.

Tinker, MT, W Raymond, JL Bodkin, GG Esslinger, DH Monson, BP Weitzman, V Gill, Z Hoyt, G Eckert, B Benter, and M Kissling. 2017. Spatial variation in harvest mortality and density dependent processes drive patterns of sea otter recovery in Southeast Alaska. Marine Mammal Conference, Halifax, Nova Scotia, Canada, 22-27 October 2017.

Esslinger GG, HA Coletti, JL Bodkin, DH Monson, BE Ballachey, TA Dean, and D Esler. 2017. Contrasting demography and behavior of sea otter populations in the northern Gulf of Alaska. Alaska Chapter of the Wildlife Society Annual Meeting, 5-6 April 2017, Fairbanks, AK.

Esslinger GG, HA Coletti, JL Bodkin, DH Monson, BE Ballachey, TA Dean, and D Esler. 2017. Trends and equilibrium density vary among sea otter populations in the northern Gulf of Alaska. Sea Otter Conservation Workshop, 17-19 March 2017, Seattle, WA.

Williams, PJ, MB Hooten, MR Bower, JN Womble, and GG Esslinger. 2016. A Spatio-Temporal Model to Infer Colonization Dynamics, and Inform Monitoring of Sea Otters in Glacier Bay, Alaska. The Wildlife Society, Oct 15-19, 2016 Raleigh, NC.

Monson, DH 2015. Sea Otter Conservation Workshop, 27-29 Mar 2015, Seattle, Washington.

Weitzman, BP 2015. Sea Otter Conservation Workshop, 27-29 Mar 2015, Seattle, Washington.

Esslinger, G.G., B.P. Weitzman, J.L. Bodkin, K.A. Kloecker, M.T. Tinker, and J.A. Estes. 2014. Dietary patterns associated with the recolonization of sea otters in Glacier Bay. 2014 Juneau Sea Otter Conference, May 20, 2014. Juneau Center, School of Fisheries and Ocean Sciences University of Alaska Fairbanks, Juneau, Alaska. [INVITED]

Esslinger, G.G., B.P. Weitzman, J.L. Bodkin, K.A. Kloecker, M.T. Tinker, and J.A. Estes. 2014. Dietary patterns associated with the recolonization of sea otters in Glacier Bay, May 22, 2014. 2014 Prince of Wales Island Sea Otter Meeting, Klawock, Alaska. [INVITED]

Esler, D., J. Bodkin, B. Ballachey, D. Monson, G. Esslinger, K. Kloecker, S. Iverson, K. Miles, and L. Bowen. 2014. 25 years after the Exxon Valdez oil spill: recovery timelines of harlequin duck and sea otter populations. Alaska Marine Science Symposium, Anchorage, AK.

Esslinger, G.G. , B.P. Weitzman, J.L. Bodkin, K.A. Kloecker, M.T. Tinker, and J.A. Estes. 2013. Understanding the impacts of sea otters on invertebrates in Glacier Bay. The science of Southeast Alaska's sea otters: A symposium to share the latest scientific data. University of Alaska Southeast, Juneau, Alaska. [INVITED]

Weitzman, B.P., J.L. Bodkin, G.G. Esslinger, K.A. Kloecker, M.T. Tinker, and J.A. Estes. 2013. Colonization in action: understanding the impacts of sea otters on soft-sediment invertebrate communities. Alaska Marine Science Symposium, Anchorage, AK.

Esslinger, G.G., J. L. Bodkin, and J. M. Burns. 2011. Temporal variation in the body temperature of sea otters in Alaska. Sea Otter Conservation Workshop VII, 25-27 Mar 2011, Seattle, Washington.

Esslinger, G.G. Sea Otters in Glacier Bay National Park and Preserve. Presentation to Glacier Bay interpretive rangers and other staff. Glacier Bay National Park & Preserve, Gustavus, AK. April 2010. [INVITED]

Weitzman, B. P, J. L. Bodkin, G. G. Esslinger, K. A. Kloecker, M. T. Tinker, J. A. Estes. 2010. The effects of sea otter recolonization on benthic intertidal invertebrate communities in Glacier Bay, Alaska. Western Society of Naturalists, Nov 11-14, San Diego, CA.

Esslinger, G. G., J. M. Burns, D. H. Monson, J. L. Bodkin, A. R. Breton. 2009. Temporal patterns in the foraging behavior of sea otters in Prince William Sound, Alaska. Sea Otter Conservation Workshop, 20-22 Mar 2009, Seattle, Washington.

Esslinger, G. G., J. M. Burns, D. H. Monson, J. L. Bodkin, A. R. Breton. 2009. Archival time-depth data reveal seasonal variation in sea otter foraging behavior. Carnivore Conference, Nov 15-18, 2009, Denver, Colorado.

Tinker, M.T., Bodkin, J., Staedler, M., Esslinger, G., Monson, D., Bentall, G., Murray, M. 2008. Using TDR records to detect reproductive events in sea otters. Third International Biologging Science Symposium, September 1-5, 2008, Pacific Grove, CA.

Esslinger, G. G., and J. L. Bodkin. Sea otter surveys and population models. Sitka Tribe of Alaska, Marine Mammal Commission, Sitka, AK, 8-10 Feb 2006.

Bodkin, J. L., B. E. Ballachey, G. G. Esslinger, K. A. Kloecker, D. H. Monson, and H. A. Coletti. 2004. Perspectives from an invading predator: Sea otters in Glacier Bay. Glacier Bay Science Symposium 25-29 October, Juneau, AK.

Haverlack, S. G., J. L. Bodkin, G. G. Esslinger, B. P. Kelly, and D. H. Monson. 2001. Discriminating foraging dives from traveling dives of sea otters. 14th Biennial meeting of the Society for Marine Mammalogy, 28 Nov-3 Dec. 2001. Vancouver, Canada.

Bodkin, J. L., G. G. Esslinger, and D. H. Monson. 2000. Diving behavior of sea otters in southeast Alaska. Seventh Joint US-Russia sea otter workshop. 14-16 November, 2000, Monterey, CA. Abstract.

Bodkin, J. L, K. A. Kloecker, G. G. Esslinger, and D. H. Monson. 2000. Observations of sea otter foraging behavior, estimated population size, and intertidal clam and urchin abundance, density and size class distribution in Glacier Bay National Park, AK. Seventh Joint US-Russia sea otter workshop. 14-16 November, 2000, Monterey, CA. Abstract.

Bodkin, J. L., B. P. Kelly, and G.G. Esslinger. 1998. Sea otter diving depths and implications to fisheries. World Marine Mammal Conference, Monaco. 20-25 January, 1998. Abstract.

Bodkin, J. L., B. P Kelly, and G.G. Esslinger. 1997. Monitoring sea otter dives with ultra-sonic transmitters and time-depth recorders. 6th Joint Russia/U.S. sea otter workshop. 15-19 November, 1997, Forks, WA. Abstract.

Bodkin, J. L. and G. G. Esslinger. 1995. Accuracy and precision in estimating ages of sea otters using cementum layers in the first premolar. 8th Northern Furbearer Conference. Anchorage, Alaska. 3-5 May 1995. Abstract.

Posters

Coletti, H.A., D. Esler, B.E. Ballachey, J.L. Bodkin, T.A. Dean, G.G. Esslinger, K. Iken, K.A. Kloecker, B. Konar, M. Lindeberg, D.H. Monson, and B. Weitzman. 2016. Long-term monitoring of nearshore marine ecosystems in the Gulf of Alaska: Detecting change and understanding cause. Alaska Marine Science Symposium, Anchorage, AK.

Weitzman, B.P., G.G. Esslinger, J.L. Bodkin, K.A. Kloecker, , D.H. Monson, M.T. Tinker, and J.A. Estes. 2015. Implications of recolonization and food limitation for sea otters in soft-bottom habitats of Glacier Bay, AK. Alaska Marine Science Symposium, Anchorage, AK.

Ballachey, B., L. Bowen, K. Miles, G. Esslinger, M. Lindeberg, K. Kloecker, and H. Coletti. 2014. Gene transcript profiles in mussels (*Mytilus trossulus*) from Prince William Sound, Alaska, 2012 & 2013, as indicators of nearshore ecosystem health. Alaska Marine Science Symposium, Anchorage, AK.

Awards

U.S. Geological Survey Occupational Health and Safety Award of Merit – 2010
Department of the Interior Occupational Health and Safety Award of Excellence– 2010

Animal capture and handling experience

Captured >500 sea otters using dive gear in Alaska, California, and British Columbia
Captured and handled >1,000 sea otters using tangle nets in Alaska, California, and British Columbia
Captured and handled Steller sea lions, harbor seals, harbor porpoises, mule deer, marine birds, shorebirds, fresh and saltwater fishes, and marine invertebrates.

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EDUCATION:

B.A., University of Minnesota, 1967. Zoology/Chemistry
M.S., Washington State University, 1970. Zoology
Ph.D., University of Arizona, 1974. Biology/Statistics

CURRENT MEMBERSHIP IN PROFESSIONAL SOCIETIES

American Association for the Advancement of Science
Ecological Society of America
Society for Conservation Biology
Society for Marine Mammalogy

PROFESSIONAL AWARDS

Sigma Xi, 1969
Phi Kappa Phi, 1969
American Men and Women of Science, 1978
Outstanding publication, US Fish and Wildlife Service, 1978
Outstanding publication, US Fish and Wildlife Service, 1981
Betty S. Davis Conservation Award, 1987
Distinguished Alumnus Award and Lecture, University of Arizona, 1990
Exceptional Service Award, Department of the Interior, 1990
Eugene M. Schoemaker Award for Distinguished Achievement in Communication, US Geological Survey, 1997
Pew Fellow in Marine Conservation, 1999
Fellow, California Academy of Science, 1999
Meritorious Service Award, US Geological Survey, 2003
Ed Ricketts Award and Lecture, Monterey Bay National Marine Sanctuary, 2004
Director's Award, US Geological Survey, 2004
Lifetime Achievement Award, Western Society of Naturalists, 2011
C. Hart Merriam Award, American Society of Mammalogists, 2012
US National Academy of Sciences, 2014

COMMITTEES AND SERVICE

Standing Committee on Marine Mammals, American Society of Mammalogists, 1978-1982, co-chairman, 1979-1982.

Steering/Planning Committee, Marine Mammal Subgroup, US/USSR Program for Conservation of the Environment, 1976-1979.

Workshop on mammals in the sea, Bergen, Norway, "Unit ecosystems working group report", 1976. Session Chair

Otter Specialist Group, Species Survival Commission, International Union for the Conservation of Nature, 1977-present, Deputy Chairman, 1981.

Workshop on social science perspectives on managing conflicts between marine mammals and fisheries, Arroyo Grande, California. Biological problems panel member, 1981.

Third International Otter Colloquium, Santa Cruz, California, 1985, Organizing Committee

Symposium on the community ecology of sea otters, Western Society of Naturalists, Monterey, California, "Sea otters, sea urchins, and kelp beds: some questions of scale", 1985. Co-organizer of symposium with G.R. VanBlaricom.

Pacific Rim development committee. University of California, Santa Cruz, 1985-1986.

International Asian Otter Symposium. Proceedings Editor, 1988.

Southern Sea Otter Recovery Team Member, US Fish and Wildlife Service, 1989-2000

Joint U.S./Russian sea otter workshop, Wasilla, Alaska. 1993, Session Chair

Board of Editors, *Ecology/Ecological Monographs*, 1993-95

Strategic Planning Workshop for National Biological Service, Washington, D.C., 1995.

Board of Editors, *Animal Conservation*, 1997-2001

Vision Workshop for research on ocean ecology. Hosted by National Science Foundation. 1998.

Science Advisory Committee, National Center for Ecological Analysis and Synthesis, National Science Foundation, 1999-2002

Committee member, NRC, National Academy of Sciences, *Relationships between fisheries and Steller sea lions*, 2001-2002.

Board of Editors, *Frontiers in Ecology and the Environment*, 2003-2007

Editor-in-Chief, *Marine Mammal Science*, 2005-2008

Member Recovery Team, Southwest Alaska Sea Otter, 2005-2010

Board of Governors, Wildland Network, 2010-present

Steering Committee, 2011 Mote Fisheries Symposium

Steering Committee, Yale Climate and Energy Conference: Managing Species for Regulating the Carbon Cycle, 2012

Board of Editors, *Proceedings of the National Academy of Sciences*, 2015-

Committee member, NRC, National Academy of Sciences, *Multiple Stressors on Marine Mammals,* 2015-2016.

Member, Ocean Studies Board, National Research Council, 2016-

Editorial Board, *Annual Review of Ecology Evolution and Systematics*, 2018 -

CONTRACTS AND GRANTS

1964-1965. National Defense and Education Association, Graduate Research Fellowship, Washington State University

1967. National Science Foundation, Summer Traineeship, Washington State University

1970-1972. (with N.S. Smith) Energy Research and Development Administration, Research on sea otters at Amchitka Island, Alaska[redacted]

1984-1985. (with G.R. VanBlaricom) National Geographic Society, Interactions between sea otters and intertidal mussel populations in Prince William Sound, Alaska ([redacted]

1985. (with M. Riedman) The Banbury Foundation, Behavior and population biology of sea otters near Monterey Bay, California [redacted])

1985-1987. (with D.O. Duggins and C.A. Simenstad) National Science Foundation, Sea otters, alternative communities, and the role of kelp-derived carbon in nearshore food webs ($[redacted]

1986. (with M. Riedman) The Banbury Foundation, Behavior and population biology of sea otters near Monterey Bay, California ([redacted])

1986-1987. (with D.O. Duggins and C.A. Simenstad) National Science Foundation, The impact of sea otters on nearshore food webs and the role of kelp-derived carbon in coastal ecosystems: secondary production supplement ([redacted]

1987-1988. (with J.S. Pearse) City of Santa Cruz, Study of the behavior and population biology of sea otters in relation to activities associated with construction of the Santa Cruz Sewage Outfall ($[redacted]

1990-1992. (with P.D. Steinberg) National Science Foundation, Geographical variation in the effects of brown algal secondary metabolites on temperate marine herbivores ([redacted]

1991-1993. (with D.B. Siniff) National Science Foundation, The behavioral ecology of sea otters at Amchitka Island, Alaska [redacted]

1995. Legacy Program, U.S. Navy, The behavioral ecology of sea otters at Adak Island, Alaska. ([redacted])

1995-97. Legacy Program, U.S. Air Force, The ecology of sea otters and coastal marine communities at Shemya Island, Alaska. [redacted])

1996-97. (with W. Jarman) U.S. Navy, Contaminant levels in blue mussels in the Aleutian Archipelago. [redacted]

1997-1999. (with W. Jarman) U.S. Navy, Spatial variation in contaminant levels in sea otters based on measurements from blood samples of living animals. [redacted].

1999-2002. (with R.G. Anthony, J.R. Bodkin, W. Jarman and A.K. Miles) U.S. Navy. Monitoring program for environmental contaminants in the nearshore marine ecosystem at Adak Island, Alaska. ([redacted])

2000-2004. (with D. Croll and J. Maron) National Science Foundation. Introduced foxes and seabirds: the role of top-down processes in controlling marine subsidies to terrestrial ecosystems. ([redacted]).

2000-2003. (with T. Williams, D. Costa, K. Ralls, and D. Siniff) Minerals Management Service. Population dynamics and biology of the California Sea Otter at the southern end of its range. ([redacted]

2008-2010 (with B. Konar and M. Edwards) National Science Foundation. Kelp forest interaction webs in the Aleutian archipelago: patterns and mechanisms of change following the collapse of an apex predator. ([redacted].

2008-2009 (with J. Bodkin) North Pacific Research Board. Threatened southwest Alaska sea otter stock: delineating the causes and constraints to recovery of a keystone predator in the North Pacific Ocean. ([redacted])

2013-2015 (with R. Steneck) National Science Foundation. Ocean acidification: century scale impacts to ecosystem structure and function of Aleutian kelp forests. ($[redacted]

INVITED SEMINARS

Institute of Arctic Biology, University of Alaska; Department of Biology, The Pennsylvania State University; Moss Landing Marine Laboratories; Department of Biology, University of California, Santa

Cruz; Department of Zoology, Oregon State University; Department of Biology, Sacramento State University; Denver Wildlife Research Center; National Marine Mammal Laboratory, Seattle; Museum of Vertebrate Zoology, University of California, Berkeley; Department of Zoology, University of Washington; Department of Biology, University of Victoria; Division of Natural Sciences, University of Victoria; Hopkins Marine Station, Stanford University; Scripps Institution of Oceanography; Department of Fisheries and Wildlife, Oregon State University; Department of Paleontology, University of California, Berkeley; Department of Biology, San Diego State University; Institute of Marine Sciences, University of North Carolina; Duke University Marine Laboratory; Institute of Marine Sciences, State University of New York at Stony Brook; Department of Ecology and Behavioral Biology, University of Minnesota; Department of Zoology, University of Auckland; Leigh Marine Laboratory, University of Auckland; Department of Renewable Natural Resources, University of Arizona; Department of Biology, Stanislaus State University; Bodega Marine Laboratory, University of California; Department of Biological Sciences, University of California at Santa Barbara; Santa Cruz Natural History Society; National Ecology Research Center; Alaska Fisheries and Wildlife Research Center; University of California at Davis; Institute of Ecosystem Studies, Millbrook, New York (2 seminars); Department of Integrative Biology, University of California, Berkeley; Department of Biology, University of Nevada, Reno; Department of Biology, University of Durham, UK; Department of Biology, Boise State University; Department of Wildlife Biology, University of Montana; Department of Biology, UCLA; Universidad Católica, Santiago, Chile; Valpariso University, Valpariso, Chile; Georgia Tech University; Darling Marine Center, University of Maine; Department of Biology, University of Pennsylvania; Department of Ecology and Evolutionary Biology, University of Minnesota; Department of Biology, University of Denver; Marine Sciences Center, University of Texas, Port Aransas; Humboldt State University; NOAA Fishery Science Center, Seattle; Stanford Law School; Duke University Marine Laboratory, Beaufort, North Carolina; Institute of Marine Sciences, University of Alaska, Fairbanks; Department of Biology, University of Alaska, Juneau; University of California, Bodega Marine Laboratory; Department of Fisheries and Wildlife, Oregon State University; Department of Biology, San Diego State University; Department of Fisheries and Wildlife, Iowa State University; Department of Biology, Georgia Institute of Technology; Department of Ecology and Evolution, Cornell University; Department of Fisheries and Wildlife, Cornell University; Marine Biology Laboratory, Woods Hole Oceanographic Institution; Department of Natural Resources, University of California Berkeley; Department of Biology, University of Wyoming; Department of Biology, Chapman College; Department of Fisheries and Wildlife, Oregon State University; The American Museum of Natural History, New York City; The Wildlife Conservation Society, Bronx Zoo; University of Nevada, Reno; Moss Landing Marine Laboratories; University of California, Berkeley; Georgia Tech University; University of Florida; Princeton University; University of Pennsylvania; State University of New York, Stony Brook; Scripps Institution of Oceanography; California State University, Northridge; University of British Columbia; CCIMAR, La Paz, Mexico; Santa Barbara City College; University of Maine; Hopkins Marine Station, Stanford University; Utah State University; University of Alaska; University of New Mexico; University of California, Los Angeles; Colorado State University; University of California, Santa Barbara; University of Nebraska; Moss Landing Marine Laboratories; Kansas State University; Institute of Ecosystem Studies ; University of Wisconsin ; University of Idaho; Oregon State University; Princeton University; West Chester University; University of Victoria; Simon Fraser University; Yale University

TEACHING

1984-1997. Probability, sampling and experimental design. University of California, Santa Cruz

1985. Stability in ecological systems. Graduate level seminar course, University of California, Santa Cruz

1987. Plant/Herbivore Interactions: marine-terrestrial comparisons. Graduate Seminar Course, University of California, Santa Cruz.

1989. Community Ecology (Diamond and Case, eds). Graduate Seminar, University of California, Santa Cruz

1997. Experiments in Ecology (A.J. Underwood). Graduate Seminar, University of California, Santa Cruz

1998. Method in Ecology (Shrader-Frechette and McCoy). Graduate Seminar Course, University of California, Santa Cruz

2000. Design of protected areas on land and in the sea. Graduate Seminar, University of California, Santa Cruz

2010-present. General Ecology. University of California, Santa Cruz

2010. Trophic Cascades. (Terborgh and Estes). Graduate Seminar, University of California, Santa Cruz

2011. General Ecology. University of California, Santa Cruz

2012. General Ecology. University of California, Santa Cruz

2013. General Ecology. University of California, Santa Cruz

2014. Controversies in conservation, graduate seminar, UC Santa Cruz; Graduate training course, UC Santa Cruz (2014 to present)

2017 Graduate student training course, preparation for Qualify Examination, UC Santa Cruz

GRADUATE STUDENTS SUPERVISED

James P. Thompson, M.S., 1982. Thesis title, "Benthic illumination within a Macrocystis bed at Pt. Soquel, Santa Cruz, California, and its influence upon Macrocystis population structure and the abundance of benthic red algae". Institute of Marine Sciences, University of California, Santa Cruz.

Cynthia Zabel, Ph.D., 1986. Dissertation title, "Reproductive behavior of the red fox (*Vulpes vulpes*): a longitudinal study of an island population". Department of Biology, University of California, Santa Cruz.

Spencer James Taggart, Ph.D., 1987. Dissertation title, "Grouping behavior of Pacific walruses (*Odobenus rosmarus divergens* Illiger), an evolutionary perspective". Department of Biology, University of California, Santa Cruz.

Claire Michaels, M.S., 1988. Thesis title, "Foraging and habitat use by the herbivorous shore crab, *Pachygrapsus crassipes*, at San Nicolas Island, California". Institute of Marine Sciences, University of California, Santa Cruz.

Carolyn B. Heath, Ph.D. 1989. Dissertation title, "The behavioral ecology of the California sea lion (*Zalophus californianus*)". Department of Biology, University of California, Santa Cruz.

Kathy J. Lyons, Ph.D. 1991. Thesis title, "Foraging behavior of California sea otters: the importance of individual variation". Institute of Marine Sciences, University of California, Santa Cruz.

Frank Winter, M.S. 1991. Thesis title, "Polyphenolics from the kelp *Dictyoneurum californicum* deter grazing by the red abalone, *Haliotis rufescens*". Institute of Marine Sciences, University of California, Santa Cruz.

Jane Watson, Ph.D. 1993. Dissertation title, "Predation and the ecology of kelp forest communities in British Columbia". Department of Biology, University of California, Santa Cruz.

Diane Carney, M.S. 1991. Thesis title, "Behavior, ecology, and reproduction of red sea urchins in Sitka Sound, Alaska". Institute of Marine Sciences, University of California, Santa Cruz.

Breck Tyler, M.S. 1991. Thesis title, "Behavioral ecology of tropicbirds in the northwest Hawaiian Islands". Institute of Marine Sciences, University of California, Santa Cruz.

Laura McShane, M.S. 1991. Thesis title, "A spectrographic analysis of vocalization in the sea otter". Institute of Marine Sciences, University of California, Santa Cruz.

Maria Sanchez, M.S. 1992. Thesis title, "Geographical variation in sea otters based on mitochondrial DNA". Institute of Marine Sciences, University of California, Santa Cruz.

Corinne Bacon, M.S. 1994. Thesis title, "An ecotoxicological comparison of organic contaminants in sea otters (*Enhydra lutris*) among populations in California and Alaska".

Institute of Marine Sciences, University of California, Santa Cruz.

Daniel H. Monson, M.S. 1995. Thesis title, "Reproductive strategies in sea otters at Amchitka Island, Alaska. Institute of Marine Sciences, University of California, Santa Cruz

Greg Golet, Ph.D. 1999. Dissertation title, "The cost of reproduction in Black Legged Kittiwakes. Institute of Marine Sciences, University of California, Santa Cruz.

Brenda Konar, Ph.D.1998. Dissertation title, "Patterns and mechanisms of succession in subarctic kelp forest communities of the northwest Pacific Ocean". Biology Department, University of California, Santa Cruz.

Steven Lee, M.S. 1995. Thesis title, "Diel activity patterns in sea urchins: an analysis of causality based on biogeographic, taxonomic, and ecological evidence". Institute of Marine Sciences, University of California, Santa Cruz.

Kenneth Vicknair, M.S. 1996. Thesis title, "Sea otters and asteroids in the western Aleutian archipelago". Institute of Marine Sciences, University of California, Santa Cruz.

Michelle Paddack, M.S. 1997. Thesis title, "The importance of refuges to coastal rockfish populations in the Monterey Bay National Marine Sanctuary". Institute of Marine Sciences, University of California, Santa Cruz, CA.

Claire Mathews, M.S. 1996. Thesis title, "Time-energy analyses of sea otter foraging in Monterey Bay, California". Institute of Marine Sciences, University of California, Santa Cruz.

Stacey Lindeman, M.S. 1998. Thesis title, "Evidence for the source of high concentrations of organic contaminants in the Aleutian archipelago based on a spatial analysis of organochlorine levels in blue mussels". Institute of Marine Sciences, University of California, Santa Cruz.

Mathew Edwards, Ph.D. 2001. Dissertation title. “Patterns and mechanism of change in giant kelp forests resulting from the 1997-98 ENSO event”. Department of Ecology and Evolutionary Biology, University of California, Santa Cruz

Shauna Risewietz, M.S. 2002. Thesis title. Shifts in kelp forest fishes and their associated food webs following collapse of sea otter populations in western Alaska. Institute of Marine Sciences, University of California, Santa Cruz

Eric Danner, Ph.D. Dissertation title, “Remote imaging analyses and landscape patterns in island plant communities”. Department of Ecology and Evolutionary Biology, University of California, Santa Cruz

M. Timothy Tinker. Ph.D. Dissertation title. “Behavior and spatial dynamics of the California sea otter population”. Department of Ecology and Evolutionary Biology, University of California, Santa Cruz

Alisha Kage, M.S. 2004, Thesis title, Movement patterns of sea otters. Department of Ecology and Evolutionary Biology, University of California, Santa Cruz.

Gena Bentall, M.S. 2005. Thesis title, Morphological and behavioral correlates of population status in the southern sea otter, *Enhydra lutris nereis:* a comparative study between central California and San Nicolas Island

Hoyt Peckham, Ph.D 2009. Dissertation topic. Behavior, ecology and conservation of loggerhead turtles on the west coast of Baja California, Mexico. Department of Ecology and Evolutionary Biology, University of California, Santa Cruz

Michelle Staedler, M.S. 2011. Thesis title. Behavioral ontogeny of sea otter pups. Department of Ecology and Evolutionary Biology, University of California, Santa Cruz.

Lilian Carswell, M.S. 2010. Thesis title. Population biology of translocated sea otters in southern California. Department of Ecology and Evolutionary Biology, University of California, Santa Cruz.

Erin Dodd, M.S. 2010. Contaminants in California sea otters. Department of Ecology and Evolutionary Biology, University of California, Santa Cruz.

Benjamin Weitzman, M.S. 2012. Thesis title. The recovery of sea otters in Glacier Bay, Alaska Department of Ecology and Evolutionary Biology, University of California, Santa Cruz.

Maxine Tarjan (co-advised with M.T. Tinker). Ph.D. Dissertation in progress. Department of Ecology and Evolutionary Biology, University of California, Santa Cruz

Sarah McKay Strobel (co-advised with M.T. Tinker and C. Reithmuth). Ph.D. Dissertation in progress. Department of Ecology and Evolutionary Biology, University of California, Santa Cruz.

INVITED TALKS AND LECTURES AT SCIENTIFIC MEETINGS

1977. "Research on the sea otter in Alaska". First working meeting of the Otter Specialist Group, IUCN, Paramaribo, Suriname,

1979. "The role of sea otters in coastal community structure". Biennial Meeting of La Sociedad Mexicana para el Estudio de los Mamiferos Marinos, La Paz, Baja California Sur

1980. "Food selection and some foraging tactics of sea otters". International Furbearer Conference, Frostburg, Maryland

1980. Workshop to examine the need for and alternatives to the culling of wild animals, Yarmouth Port, Mass., "The case of the sea otter".

1981. "Las Nutrias del mar, las pesquerias y la organizacion del medio ambiente marino al sur de Punta Concepcion, California". Sociedad Mexicana para el Estudio de los Mamiferos Marinos, La Paz, Baja California Sur

1983. "Sea otters and invertebrate fishery resources: existing and potential conflicts from Canada to Mexico". Workshop on conflicts between marine mammals and fisheries, La Jolla, California.

1987. "Multicausal disturbances and the non-equilibrium structure of a rocky intertidal community at San Nicolas Island, California". California Islands Symposium, Santa Barbara, California

1988. “Research and management of sea otters in the eastern North Pacific Ocean”. International Asian Otter Symposium, Bangalore, India.

1988. “Ecology of extinctions in kelp forest communities”. Annual meeting of the Society for Conservation Biology, Davis, California.

1989. “Sampling and resource assessment in rocky intertidal communities”. Annual Meeting of the Southern California Academy of Sciences, Thousand Oaks, California.

1989. “Population status of the sea otter”. Fifth International Otter Colloquium, Hankensbüttel, Germany.

1989. "Homing behavior of sea otters relocated to San Nicolas Island". International Theriological Congress, Rome, Italy.

1989. “Behavior, ecology and life history of New World otters”. Fifth International Otter Colloquium, Hankensbüttel, Germany.

1991. “Paradigms for managing carnivores: the case of the sea otter”. Zoological Society of London, Symposium, London. INVITED

1992. "The role of plant secondary compounds in marine plant-herbivore interactions: an interhemispheric comparison". Temperate Reef Symposium, Auckland, New Zealand

1992. “Ecology, economics and history: the Pacific maritime fur trade”. Public lecture series for distinguished alumni, University of Arizona.

1993. "The evolutionary consequences of sea otters in kelp forest communities." Joint U.S./Russian sea otter workshop, Wasilla, Alaska

1993. "Environmental contaminants in sea otters." Joint U.S./Russian sea otter workshop, Wasilla, Alaska

1993. “Top-level carnivores and ecosystem effects: questions and approaches”. Cary Conference on *Linking Species and Ecosystems*, Institute of Ecosystem Studies, Milbrook, New York.

1994. “Influences of large, mobile predators in aquatic communities: examples from sea otters and kelp forests”. Royal Society of Scotland, Symposium on predator/prey interactions in aquatic ecosystems, Aberdeen, Scotland. INVITED

1994. "Marine mammals: an overview of research needs in central California." Workshop on the Monterey Bay Research Initiative, University of California, Santa Cruz.

1994. "The search for keystone species". Workshop on keystone species, UNEP Global Biodiversity Assessment, Hilo, Hawaii.

1995. “Sea otters as a keystone species”. Plenary lecture, Annual meeting of the Wildlife Society, Portland, Oregon.

1995. "Careers in conservation." Western Regional Meeting of AAAS/Society for Conservation Biology.

1996. "The NBS research program on sea otters". California Biodiversity initiative, Monterey Bay National Marine Sanctuary.

1996. "Comparative demography of sea otter populations". Workshop on the sea otter, Endangered Species Update, Monterey Bay Aquarium.

1997. “Sea otters as umbrella species in the conservation of kelp forest ecosystems”. Symposium on species and ecosystem approaches to management. Annual Meeting of the Society for Conservation Biology, Victoria, British Columbia.

1997. “Catastrophic declines in sea otter populations in the Aleutian archipelago”. Monterey Bay Biodiversity Symposium, Santa Cruz, CA.

1997. “Do sea otters make a good umbrella species for the conservation of kelp forest ecosystems?” International Theriological Congress, Acapulco, Mexico.

1997. “Why rehabilitate oiled wildlife?” 5th International symposium on wildlife and oil spills. Monterey, California, 3-5 November 1997.

1998. “Why predators matter”. Keynote Lecture. Grass roots meeting of the Wildlands Project, Estes Park. Colorado.

1998. “Sea otters and kelp forests”. Public lecture series of the US Geological Survey, Menlo Park.

1999. “Predators and ecosystems”. Sigma Xi Lecture, University of California, Santa Cruz.

2000. “Predation in the sea”. Inaugural Lecture of the Seymour Marine Discovery Center, University of California, Santa Cruz.

2000. “Apex predators and trophic cascades in some marine and terrestrial ecosystems”. Society for Conservation Biology Annual Meeting, Missoula, Montana.

2000. “Apex predators, ecosystem connectivity, and the optimal size of marine reserves”. Plenary Lecture, American Fisheries Society, Fairbanks.

1999. “Status of sea otters in the Aleutian Islands”. US/Russia joint sea otter meeting, Monterey.

2001. “Tales of past abundance: an Alaskan story”. Colloquium on Marine Conservation, Monterey Bay Aquarium.

2001. “Predators and ‘the balance of nature’”. Schweppe Public Lecture Series in marine sciences, University of Texas, Port Aransas, Texas.

2001. “Predators and the balance of nature”. Distinguished Marine Scientist Colloquium, Hatfield Marine Sciences Center, NOAA and Oregon State University.

2001. “Predators and the balance of nature”. Peter Leveque Natural History Lecture, Santa Rosa Junior College.

2001. “Chain reactions in kelp forests: long ago and far away”. American Association for the Advancement of Science, Annual Meeting.

2002. “Complex interactions in kelp forest ecosystems”. Plenary Lecture, *Carnivores 2002*, Conference sponsored by Defenders of Wildlife, Monterey, California.

2002. “Process advocacy colors scientific objectivity”. 2002 Annual Pew Fellows meeting, Plenary Lecture. Bonnaire, Dutch West Indies.

2002. “Complex trophic relationships in kelp forests”. 4th William R. and Lenore Mote International Symposium in Fishery Ecology, Sarasota, Florida. *Confronting tradeoffs in the ecosystem approach to fisheries management.*

2002. “Some historical dimensions to kelp forest ecosystem dynamics”. Western Society of Naturalists, Annual Meeting. Symposium on historical ecology.

2003. “Defaunated food webs: large vertebrates and nature’s balance”. 17th Annual Ricketts Memorial Lecture. Presented by the Research Community of Monterey Bay for exemplary work in the field of marine sciences.

2003. “Defaunated food webs: large vertebrates and nature’s balance”. Plenary lecture. Oregon State University, Department of Fisheries and Wildlife, Annual Graduate Student Colloquium, November 12, 2003.

2003. “Carnivory and connectivity in ‘pristine’ island food webs”. Keynote lecture, 6th California Islands Symposium, Ventura, California.

2003. “Sequential megafaunal collapse in the North Pacific Ocean: an ongoing legacy of commercial whaling?”. Plenary lecture, 15th Biennial Conference on the Biology of Marine Mammals, Greensboro, North Carolina.

2004. “Large vertebrates and nature’s balance”. 40th Annual Paul L. Errington Memorial Lecture, Iowa State University.

2004. From killer whales to kelp forests: industrial whaling and the reorganization of ocean ecosystems Capstone Lecture, Annual Meeting, American Society of Mammalogists. Arcata, California.

2004. Large predators and ecosystem resilience: examples and hypotheses from 3 case studies. Symposium on the resilience of marine ecosystems honoring the 100th

anniversary of Friday Harbor Laboratories, University of Washington.

2004. Sea otters: science, policy and the future. Keynote lecture for sea otter awareness week. Sponsored by Defenders of Wildlife, Monterey, CA

2005. From killer whales to kelp forests: connectivity in marine food webs. Spring Colloquium in Biology, University of North Carolina, Greensboro.

2005. Population status of sea otters. Keynote lecture for sea otter awareness week. Sponsored by Defenders of Wildlife, Monterey, CA

2005. From killer whales to kelp forests; chain reactions in ocean ecosystems. Distinguished Scientist Lecture, Marine Biological Laboratory, Woods Hole.

2005. The influences of large vertebrates in marine and terrestrial ecosystems. American Association for the Advancement of Science, Annual Meeting.

2006. Repatriating functionality in global ecosystems. Plenary Lecture, Annual Meeting, Society for Conservation Biology.

2006. Sea otters as predators and prey: the causes and consequences of trophic cascades. Annual Meeting, The Wildlife Society.

2009. The Aleutian archipelago: understanding carnivory from patterns of variation in space and time. Symposium on the Ecology of Place, Annual Meeting, The Ecological Society of America.

2009. Trophic downgrading of planet earth. Plenary Lecture, Annual Meeting, Western Society of Naturalists.

2010. Trophic downgrading of our planet. Plenary Lecture. Marine Biology Symposium, University of Florida, St. Augustine Marine Lab.

2011. Apex consumers and the fabric of nature. Vice President's Symposium, Society of American Naturalists/Society for the Study of Evolution, annual meeting, Norman, Oklahoma.

2012. Do trophic cascades affect the sequestration and storage of atmospheric carbon: an analysis for sea otters and kelp forests. Yale climate and energy annual conference, Yale University.

2013. Sea otters and kelp forests: an ecological history of the North Pacific Ocean. C. Hart Merriam Lecture, American Society of Mammalogists Annual Meeting, Philadelphia, PA.

2013. Trophic level complexity and its influence on population dynamics and conservation. International Mammalogical Congress, Belfast, Northern Ireland.

2014. Sea otters and kelp forests: questions, approaches, and perspectives. Hakai Institute, British Columbia

2015. The keystone species concept in ecology and management. Ecological Society of America, Annual Meeting.

2016. Adventures in nature and the pathways to ecological understanding. Western Society of Naturalists, Annual Meeting

2017. Ecology and Conservation Biology: A 50 retrospection on change. Plenary Lecture, Society for Conservation Biology, California Chapter.

2017. Serpentine food web pathways, or R.T. Paine's influence on my view of nature. Commemorative Symposium on the life and influence of Robert T. Paine, Ecological Society of America, Annual Meeting.

2018. Megafauna: the science behind big animals and why they matter. G.E. Hutchinson invited lecture. Yale University

PUBLICATIONS

Buss, I.O., and J.A. Estes. 1971. Functional significance of ear pinnae movements in the African elephant. *J. Mammal.* 52: 21-27.

Estes, J.A., and J.F. Palmisano. 1974. Sea otters: their role in structuring nearshore communities. *Science* 185: 1058-1060.

Morrison, P., M. Rosenman, and J.A. Estes. 1975. Metabolism and thermoregulation in the sea otter. *Physiol. Zool.* 47: 218-229.

Sherrod, S., J.A. Estes, and C.M. White. 1975. Depredation of sea otter pups by bald eagles at Amchitka Island, Alaska. *J. Mammal.* 56: 701-703.

Estes, J.A., and I.O. Buss. 1976. Microanatomical development and structure of the African elephant's temporal gland. *Mammalia* 40: 429-436.

Palmisano, J.F., and J.A. Estes. 1976. Sea otters: pillars of the nearshore community. *Natural History* 85: 46-53.

Estes, J.A. 1977. Population estimates and feeding behavior of sea otters, pp. 511-526 in M.L. Merritt and R.G. Fuller (eds.). The Environment of Amchitka Island. USERDA, TID-26712, Springfield, Virginia.

Palmisano, J.F., and J.A. Estes. 1977. Ecological interactions involving the sea otter. pp. 527-567 in M.L. Merritt and R.G. Fuller (eds.). The Environment of Amchitka Island. USERDA, TID-26712, Springfield, Virginia.

Simenstad, C.A., J.A. Estes, and K.W. Kenyon. 1978. Aleuts, sea otters, and alternate stable state communities. *Science* 200: 403-411.

Estes, J.A., and J.R. Gilbert. 1978. Evaluation of an aerial survey of Pacific walruses. *J. Fish Res. Board Can.* 35: 1130-1140.

Estes, J.A., N.S. Smith, and J.F. Palmisano. 1978. Sea otter predation and community organization in the western Aleutian Island, Alaska. *Ecology* 59: 822-833.

Estes, J.A. 1979. Exploitation of marine mammals: r-selection of K-strategists? *J. Fish Res. Board Can.* 36: 1209-1217.

Estes, J.A. 1980. *Enhydra lutris*. *Mammalian Species* No. 137, pp. 108, 3 Figs.

DeMaster, D.P., J.B. Faro, J.A. Estes, S.J. Taggart, and C. Zabel. 1981. Drug immobilization of walrus (*Odobenus rosmarus*). *Can. J. Fish Aq. Sci*. 38: 365-367.

Estes, J.A. 1981. Carnivorous mammals: the case of the sea otter. in P.A. Jewell and S. Holt (eds.). The Management of Locally Abundant Wild Mammals, Academic Press, New York.

Estes, J.A., R.J. Jameson, and A.M. Johnson. 1981. Food selection and some foraging tactics of sea otters. pp. 606-641 in J.A. Chapman and D. Pursley (eds.). Worldwide Furbearer Conference Proceedings, Worldwide Furbearer Conference, Inc. Frostburg, Maryland.

Estes, J.A., R.J. Jameson, and E.B. Rhode. 1982. Activity and prey selection in the sea otter: influence of population status on community structure. *Amer. Nat.* 120: 242-258.

Estes, J.A., and R.J. Jameson. 1983. Summary of available population information on California sea otters. U.S. Dept. of Interior, Minerals Management Service, POCS Technical Paper 83-11.

Estes, J.A., and V. Gol'tsev. 1984. Abundance and distribution of the Pacific walrus:

results of the first Soviet/American joint aerial survey, autumn 1975. pp. 67-76 in F.H. Fay and G.A. Fedoseev (eds.). Soviet-American cooperative research on marine mammals. Vol. 1 - Pinnipeds. NOAA Tech. Rept. NMFS 12.

Estes, J.A., and G.R. VanBlaricom. 1985. Sea otters and shellfisheries. pp. 187-235 in R.H. Beverton, D. Lavigne, and J. Beddington (eds.). Conflicts between marine mammals and fisheries. Allen and Unwin, London.

Estes, J.A. 1986. Marine otters and their environment. *Ambio* 15: 181-183.

Estes, J.A. 1986. Otters. Ecology and Conservation, by C.F. Mason and S.M. Macdonald. (Book Review) *Science* 223: 1333-1334.

Estes, J.A. 1986. The natural history of otters, by P. Chanin. (Book Review) *Am. Sci.* 74: 300-301.

Estes, J.A., K.E. Underwood, and M.J. Karmann. 1986. Activity-time budgets of sea otters in California. *J. Wildl. Mgmt.* 50: 626-636.

Irons, D.B., R.G. Anthony, and J.A. Estes. 1986. Foraging strategies of Glaucous-winged Gulls in rocky intertidal communities. *Ecology* 67: 1460-1474.

Lindberg, D.R., K.I. Warheit, and J.A. Estes. 1987. Seasonal predation and prey preference by oystercatchers on limpets at San Nicolas Island, California, USA. *Mar. Ecol. Prog. Ser.* 39:105-113.

Riedman, M., and J.A. Estes. 1988. A review of the history, distribution, and foraging ecology of sea otters. Pp. 4-21 in G.R. VanBlaricom and J.A. Estes (eds.). The community ecology of sea otters. Ecological Studies Vol. 65. Springer Verlag, New York.

Estes, J.A., and C. Harrold. 1988. Sea otters, sea urchins, and kelp beds: some questions of scale. Pp. 116-150 in G.R. VanBlaricom and J.A. Estes (eds.). The community ecology of sea otters. Ecological Studies Vol. 65. Springer Verlag, New York.

VanBlaricom, G.R., and J.A. Estes (eds.). 1988. The community ecology of sea otters. Ecological Studies Vol. 65. Springer Verlag, New York.

Estes, J.A., and P.D. Steinberg. 1988. Predation, herbivory and kelp evolution. *Paleobiology* 14: 19-36.

Estes, J.A., and G.R. VanBlaricom. 1988. Concluding Remarks. Pp. 210-218 in G.R. VanBlaricom and J.A. Estes (eds.). The community ecology of sea otters. Ecological Studies, Vol. 65. Springer Verlag, New York.

Riedman, M., and J.A. Estes. 1988. Predation on sea birds by sea otters. *Can. J. Zool.* 66: 1396-1402.

Estes, J.A., and R.J. Jameson. 1988. A double survey estimate for sighting probability of sea otters in California. *J. Wildl. Mgmt.* 52: 70-76.

Estes, J.A. 1989. Adaptations for aquatic living in carnivores. Pp. 242-282 in J.L. Gittleman (ed.). Carnivore behavior ecology and evolution. Cornell University Press.

Duggins, D.O., C.A. Simenstad, and J.A. Estes. 1989. Magnification of secondary production by kelp detritus in coastal marine ecosystems. *Science* 245:170-173.

Estes, J.A. and P.D. Steinberg. 1989. Response to Domning. *Paleobiology* 15:57-60.

Estes, J.A., D.O. Duggins, and G. Rathbun. 1989. The ecology of extinctions in kelp forest communities. *Conservation Biology* 3:252-264.

Miller, K.A. and J.A. Estes. 1989. A western range extension for *Nereocystis leutkeana* in the North Pacific. *Botanica Marina* 32:535-538.

Estes, J.A. 1990. Growth and equilibrium in sea otter populations. *J. Animal Ecol.* 59:385-400.

Estes, J.A. 1990. Assessment of sea otter population status: a reply. *J. Wildl. Manage.* 54:270-272.

Smith, D.R., S. Niemeyer, J.A. Estes, and A.R. Flegal. 1990. Stable lead isotopes evidence anthropogenic contamination in Alaskan sea otters. *Environ. Sci. Tech.* 24:1517-1521.

Riedman, M.L., and J.A. Estes. 1990. The sea otter (*Enhydra lutris*): behavior, ecology, and natural history. *Biological Report* 90(14), U.S. Fish and Wildlife Service. 126pp.

Estes, J.A. 1991. Catastrophes and conservation: Lessons from sea otters and the *Exxon Valdez*. *Science* 254:1596.

Winter, F.C., and J.A. Estes. 1992. Experimental evidence for the effects of polyphenolic compounds from *Dictyoneurum californicum* (Phaeophyta; Laminariales) on feeding rate and growth in the red abalone (*Haliotus rufescens*). *J. Exp. Mar. Biol. Ecol.* 155:263-277.

Estes, J.A. 1992. Behavior, ecology, and life history of New World otters. pp. 107-117 in C. Reuther and R. Rochert (eds.), Proceedings of the V. International Otter Colloquium, Hankensbuttel. Habitat 6.

Estes, J.A. 1992. Status of sea otter (*Enhydra lutris*) populations. pp. 27-35 in C. Reuther and R. Rochert (eds.), Proceedings of the V. International Otter Colloquium, Hankensbuttel. Habitat 6.

Estes, J.A., G.B. Rathbun, and G.R. VanBlaricom. 1993. Paradigms for managing carnivores: the case of the sea otter. *Symp. Zool. Soc. Lond.* 65:307-320.

Riedman, M.L., J.A. Estes, M. Staedler, A. Giles, and D. Carlson. 1994. Breeding patterns and reproductive success of sea otters in California. *J. Wildl. Manage.* 58:391-399.

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FILMS AND VIDEOS

http://www.hhmi.org/biointeractive/some-animals-are-more-equal-others-keystone-species-and-trophic-cascades. Howard Hughes Medical Institute

http://www.ibiology.org/ibioseminars/ecological-function-apex-predators-part-1.html

The Serengeti Rules. A feature-length documentary film on keystone species and trophic cascades, scheduled for release in early 2018. Supported by HHMI and Produced by Passion Pictures, London. The film will debut at 2018 Tribeca Film Festival.

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EDUCATION:

- **University of Florida College of Veterinary Medicine,** Gainesville, FL
  - Residency in Zoological and Wildlife Medicine, 2003-2006

  Diplomate of the American College of Zoological Medicine, 2006

- **Columbia University**, New York, NY
  - **Ph.D.** in Ecology, Evolution, and Environmental Biology, 2004

  Dissertation: Disease ecology of wild and domestic carnivores in Bolivia.
  - **Advanced Certificate** in Environmental Policy, 2001

- **Angell Memorial Animal Hospital**, Boston, MA
  - **Internship** in Small Animal Medicine and Surgery, 1999

- **Tufts University School of Veterinary Medicine**, North Grafton, MA
  - **D.V.M.**, 1998

- **University of Cincinnati**, College of Arts and Sciences, Cincinnati, OH
  - **M.S.** in Biological Sciences, 1993

  Thesis: Evolutionary morphology of craniofacial growth in three breeds of rabbit.

- **Brown University**, Providence, RI
  - **A.B.** in Biology with honors, 1990

  Thesis: Reproductive success in female black-tailed prairie dogs.

AWARDS and SCHOLARSHIPS:

- Best Poster Award, American Association of Zoo Veterinarians, 2013
- American College of Zoological Medicine Manuscript Award, 2007
- American College of Zoological Medicine Manuscript Award, 2005
- Columbia University Center for Environmental Research & Conservation Fellowship, 1999-2003
- Wildlife Medicine Award, Tufts University, 1998
- National Scholar Award, Philanthropic Educational Organization Sisterhood, 1997
- New England Farm and Garden Club Scholarship, 1996, 1997
- Outstanding Master's Student of the Year Award, University of Cincinnati, 1993

GRANTS:

- Sacramento Zoo Conservation Fund, Small Grants Program, [redacted]
- National Geographic, Co-PI, [redacted]

- Mazuri Fund, AAZV Research Grant, [redacted] 2008
- University of Georgia competitive Faculty Research Grant, [redacted], 2008
- University of Florida Resident Research Competition Grant, [redacted] 2004
- National Science Foundation Doctoral Dissertation Improvement Grant, $[redacted], 2003
- Columbia University Graduate School Summer Merit Scholarship Grant, [redacted] 2002
- Wildlife Conservation Society Jaguar Conservation Program Grant, [redacted] 2001-2003
- Tinker Foundation Summer Research Grant, $[redacted]

PROFESSIONAL EXPERIENCE:

Associate Veterinarian, Albuquerque BioPark, July 2017-present. Clinical veterinarian for Zoo and Aquarium with large, diverse collection including 3 great ape spp., an elephant breeding group, 5 big cat spp., pinnipeds, elasmobranchs, birds representing 20 orders, and both a reptile and amphibian house.

Response Veterinarian, Oiled Wildlife Care Network, School of Veterinary Medicine, University of California, Davis, May 2010-May 2017. Lead clinical veterinarian for OWCN. Director of Wildlife Health Center veterinary student externship. Responsibilities in preparedness, research, training, and response. Assisted with development of electronic medical database OWRMD for oiled wildlife response. Edited and contributed to peer-reviewed oiled wildlife care protocols for birds, sea otters, and herptiles. Scientific program chair, lecturer, and wetlab instructor for annual conference. Some teaching in DVM curriculum; mentoring of veterinary students and MPVM students. Frequent consultant to CA Fish & Wildlife Dept.

Clinical Veterinarian (part-time relief), San Francisco Zoo, CA, Aug 2011-May 2017.

Assistant Professor, University of Georgia, Oct 2007-May 2010. Tenure-track faculty member in Zoological Medicine, with responsibilities in clinical service, didactic teaching, and research. Developed new Marine Animal Medicine course. Director of native wildlife medicine program. Member of the Graduate Faculty and the interdisciplinary Faculty of Infectious Diseases.

Clinical veterinarian, Disney's Animal Kingdom, Lake Buena Vista, Florida, July 2006-July 2007. Employed through the University of Florida in one-year position as a full-time staff veterinarian for animal collections at Animal Kingdom and Epcot's Living Seas Aquarium.

Zoological Medicine Resident, University of Florida, Gainesville, 2003-2006. Clinical care of free-ranging wildlife, exotic pets, and collection animals at 4 AZA-accredited institutions: Central Florida Zoological Park, Santa Fe Teaching Zoo, St. Augustine Alligator Farm, and Lubee Bat Conservancy. Final year spent as a full-time veterinarian at White Oak Conservation Center.

Graduate Fellow, Columbia University, 1999-2003. Capture, immobilization, & sampling of free-ranging canids and felids; collaboration with local biologists and indigenous residents; analysis of domestic dog ecology; epidemiologic modeling of canine distemper virus and parvovirus transmission.

Consulting Wildlife Veterinarian

- Lambayeque, Peru, July-August 2008. Immobilization and health evaluation of captive spectacled bears; capture attempts of wild bears for satellite collaring.

- Puerto Maldonado, Peru, March 2007. Veterinary support and immobilization training for biologists on lowland tapir ecology project at Los Amigos field station in Madre de Dios.
- Barro Colorado Island, Panama, March 2002. Immobilization of ocelots for radio collar fitting. Training of field biologists in wildlife anesthetic management and animal handling.
- Monomoy National Wildlife Refuge, MA, summers 2001–2003. Veterinary support for ongoing shorebird conservation projects.

Associate Veterinarian (part-time), Riverdale Veterinary Group, NY, 2001–2003. Small and exotic animal medicine and surgery in a busy private animal hospital in New York City.

PUBLICATIONS:

Freeman, K.S., **C.V. Fiorello**, and M. Murray. 2018. Comparison of anterior segment health in wild and captive common murres. *Veterinary Ophthalmology* 21 (2): 174-181.

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Fiorello, C.V., S.E. Wade, R. Robbins. 2006. Parasites of free-ranging small canids and felids in the Bolivian Chaco. *JZWM* 37: 130-134.

Siegal-Willott, J., R. Isaza, **C. Fiorello**, D. Heard, M. Reinhard. 2006. *Mycobacterium asiaticum* in a red-handed tamarin (*Saguinus midas*). *JZWM* 37: 413-415.

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Fiorello, C.V. and R.Z. German. 1997. Heterochrony within species: Craniofacial growth in giant, standard, and dwarf rabbits. *Evolution* 51: 257-61.

BOOK CHAPTERS:

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ABSTRACTS AND OTHER PUBLICATIONS:

Fiorello, C., J. Lamb, Y. Satge, P. Jodice, K. Mills-Parker, M. Ziccardi. 2018. Post-release survival and movement of oiled and rehabilitated brown pelicans affected by the 2015 Refugio Oil Spill. Proceedings, Wildlife Disease Association, St. Augustine, FL.

Fiorello, C., P. Jodice, J. Lamb, Y. Satge, K. Mills-Parker, D. Jaques, L. Henkel, R. Golightly, M. Ziccardi. 2017. Post-release monitoring of oiled brown pelicans form the 2015 Refugio Oil Spill. Proceedings, International Oil Spill Conference, Long Beach, CA; Abst. #2017-119, 12 pp.

Ruvalcaba, C.A., R. Monroy, L.A. Tell, **C.V. Fiorello**, J. Last, and J-P. Delplanque. 2017. Comparison of liquid vs. dry aerosol drug delivery in a 3D printed avian trachea and mainstem bronchi model. Proceedings, Translational Science 2017, Washington, D.C.

Fiorello, C., P. Jodice, K. Mills-Parker, J. Lamb, R. Golightly, Y. Satge, D. Jaques, L. Henkel, R. McMorran, and M.H. Ziccardi. 2016. Post-release monitoring of brown pelicans (*Pelecanus occidentalis*) following oiling and rehabilitation after the Refugio oil spill. Proceedings, Pacific Seabird Group annual conference, Turtle Bay, HI.

Fiorello, C., P. Jodice, K. Mills-Parker, J. Lamb, R. Golightly, Y. Satge, D. Jaques, L. Henkel, R. McMorran, and M. Ziccardi. 2016. Post-release monitoring of oiled and rehabilitated brown pelicans (*Pelecanus occidentalis*) affected by the 2015 Refugo oil spill. Proceedings, The Wildlife Society Western Section annual conference, Pomona, CA.

Liu, J., E. McCown, **C. Fiorello,** D.G. Scorpio, M.. Filipovic, J. Saucier, B. Thatcher, and R. Chandrashekar. 2016**.** Serological survey of canine tick-borne infections using species-specific serological markers. Association of Rickettsiology conference, Big Sky, MT.

Fiorello, C.V., G. Massey, and M. Ziccardi. 2015. Use of in-house biomedical metrics to predict survival to release during rehabilitation of oiled seabirds. Proceedings, Effects of Oil on Wildlife Conference, Anchorage, AK.

Fiorello, C.V., K. Freeman, B. Elias, E. Whitmer, and M. Ziccardi. 2015. Ocular effects of dispersant exposure in common murres (*Uria aalge*): An experimental study. Proceedings, Effects of Oil on Wildlife Conference, Anchorage, AK.

Fiorello, C.V., L.M. Schwartz, J. Liu, A.K. Kownacki, and J. Foley. 2014. Multihost pathogens in, and jaguar predation on, domestic dogs in Nicaragua's Bosawás Biosphere Reserve. Proceedings, AAZV Annual Conference, Orlando, FL.

Fiorello, C.V. 2013. Schistosomiasis. In: Gamble, K.C., and M.M. Clancy (eds). Infectious Diseases of Concern to Captive and Free Ranging Animals in North America, 2nd ed. 2013. Infectious Disease Committee, American Association of Zoo Veterinarians, Yulee, Florida. 1098 pp. Website address: http://www.aazv.org/?page=IDM2013.

Fiorello, C.V., E. Bronson, J. Sohl, and M.H. Ziccardi. 2013. Exploration of methods for fibrinogen measurement in avian species. Proceedings, AAZV Annual Conf., Salt Lake City, UT.

Fiorello, C.V. 2013. Visceral Leishmaniasis. In: Gamble, K.C., and M.M. Clancy (eds). Infectious Diseases of Concern to Captive and Free Ranging Animals in North America, 2nd ed. 2013. Infectious Disease Committee, American Association of Zoo Veterinarians, Yulee, Florida. 1098 pp. Website address: http://www.aazv.org/?page=IDM2013.

Fiorello, C.V. and M.H. Ziccardi. 2012. Oiled wildlife response: bringing veterinarians into the fold. Proceedings, International Association of Aquatic Animal Medicine Annual Conf., Atlanta, GA.

Fiorello, C.V. 2012. Small Carnivore Sampling Methods Protocol. In: PREDICT One Health Consortium, USAID/PREDICT: http://www.vetmed.ucdavis.edu/ohi/predict/publications.cfm.

Fiorello, C.V. 2012. A review of fat soluble vitamin needs for piscivorous birds. Proceedings, Effects of Oil on Wildlife International Conference, New Orleans, LA.

Fiorello, C.V. 2012. Evidence-based veterinary medicine in oil spill response. Proceedings, Effects of Oil on Wildlife International Conference, New Orleans, LA.

Fiorello, C.V., S. Rivera, T. Clauss, B. Brainard, G. Rapoport, H. Murphy, and A. Berliner. 2011. Fully reversible anesthesia in Asian small-clawed otters using dexmedetomidine-butorphanol-midazolam and comparison of anesthetic and cardiac parameters with ketamine-midazolam. Proceedings, AAZV Annual Conf., Kansas City, MO.

Fiorello, C.V. and M.H. Ziccardi. 2011. Responding to oiled wildlife in the post-Deepwater Horizon World. Proceedings, AAZV Annual Conf., Kansas City, MO.

Backues, K., V. Clyde, M. Denver, **C. Fiorello**, R. Hilsenroth, N. Lamberski, S. Larsen, T. Meehan, J. Ramer, E. Ramsay, K. Suedmeyer, and D. Whiteside. 2011. Guidelines for zoo and aquarium veterinary medical programs and veterinary hospitals. JZWM 42(1): 176-192.

Deem, S.L., A.J. Noss, **C.V. Fiorello**. 2009. Biólogos y veterinarios de la conservación que trabajan en beneficio de los animales, las personas y el medio ambiente: Una asociación en el Gran Chaco, Bolivia. Fauna Vet Peru: Revista Virtual 2 (4): pp. 4-9.

Deem, S.L., **C.V. Fiorello**, M. Cunningham, et al. 2009, 2013. Guidelines for veterinarians interested in *in situ* conservation and free-ranging wildlife health projects. American Association of Zoo Veterinarians, http://www.aazv.org/displaycommon.cfm?an=1&subarticlenbr=20

Fiorello, C.V. 2007. Review of *Bears: Health and Management*, by D.C. Bourne and G. Vila-Garcia. JAVMA 232: 1813.

INVITED TALKS:

Fiorello, C.V. 2012. *Latin American Conservation*. UC Davis School of Veterinary Medicine Hot Topics Lecture Series, Davis, CA.

Fiorello, C.V. 2008. *Disease transmission between wildlife and domestic animals*. Eighth International Congress on Management of Wildlife of Amazonia and Latin America, Rio Branco, Brazil.

Fiorello, C.V. 2003. *Disease ecology of wild and domestic carnivores in Bolivia*. ProCarnivoros First Workshop on Neotropical Carnivore Conservation, Atibaia, Brazil.

PROFESSIONAL AFFILIATIONS & SERVICE:

- American Association of Zoo Veterinarians, member 1996-present
  - Co-chair, Research Committee, 2015-2016
  - Chair, Research Committee, 2016-2017
  - Executive Committee member, 2009-2011
  - Co-Chair, Committee on Wildlife Health and Conservation, 2008-2013
  - Infectious Disease Committee, member 2008-present
  - Session Chair, Greening of Veterinary Medicine, 2009 annual conference
  - Session Chair, Notes from the Field, 2010 annual conference
  - Session Chair, Disaster Management, 2013 annual conference
  - Strategic Planning meeting, 2015

- American College of Zoological Medicine
  - Chair, Wildlife Section of Exam Committee, 2012-present
  - Ad-hoc Committee on Training Program Standards, Structure, and Evaluation, member 2011-present

- American Association of Wildlife Veterinarians, member 2000-2016
  - Instructor, Wildlife Capture workshop, 2013
  - Annual auction coordinator, 2007, 2009
  - Co-coordinator, Tools for Veterinarians in Wildlife Field Research workshop, 2009

- Wildlife Disease Association, member 1999-present

- American Veterinary Medical Association, member 1994-present
- Reviewer for:
  - Journal of Wildlife Diseases
  - Journal of Zoo & Wildlife Medicine
  - Ecohealth
  - PLoS One
  - Journal of the American Veterinary Medical Association
  - Avian Diseases
  - Journal of Parasitology
  - Epidemiology & Infection
  - Environmental Monitoring & Assessment
  - Integrative Zoology
  - IUCN Cat News
  - Zoo Biology
  - European Journal of Wildlife Research
  - New Zealand Journal of Marine and Freshwater Research
  - Ecological Applications

GOVERNMENTAL SERVICE

- US Fish & Wildlife Service Marbled Murrelet Expert Panel and Recovery Implementation Team, member 2011-present

VETERINARY LICENSES:

- New Mexico
- California
- Massachusetts
- New York (inactive)
- USDA federally accredited

HEAT[redacted]CVPM

[redacted]

EDUCATION

2017 **Diplomate, American College of Veterinary Preventive Medicine**
Specialty board certification

2008 **Master of Preventive Veterinary Medicine: Wildlife Disease Ecology**
University of California, Davis, School of Veterinary Medicine

2006 **Doctor of Veterinary Medicine: Wildlife Medicine Track**
University of California, Davis, School of Veterinary Medicine

1996 **Bachelor of Arts: Environmental Studies**
University of California, Santa Barbara

CURRENT PROFESSIONAL LICENSES AND CERTIFICATIONS

2010-Present DEA License for Controlled Substances, Type A Practitioner

2006-Present California State Veterinary License (#16410)

2006-Present 24-HOUR HAZWOPER Certification, Oiled Wildlife Care Network

POST-DOCTORAL TRAINING

2007-2008 **Internship: Marine Mammal Medicine and Pathology, The Marine Mammal Center / UC Davis**
Provided advanced medical care to free-ranging marine mammals in a high-volume rehabilitation hospital (critical care, anesthesia, surgery, radiology, clinical care, and necropsy). Performed field anesthesia and biological sampling for collaborative research projects on remote pinniped rookeries. Conducted research studies on infectious disease surveillance and pathology. Trained and supervised veterinary students and interfaced with the media.

CURRENT POSITIONS

2015-Present **Veterinarian/Lecturer, California Polytechnic State University, San Luis Obispo, CA**
Develop and teach new hands-on courses with One Health focus for upper division undergraduate students in the Animal Science Department. Affiliated faculty with the Center for Coastal Marine Sciences. Provide veterinary support for field research on elephant seals at Piedras Blancas rookery and Weddell seals in Antarctica.

- ASCI 270: Global One Health Topics
- ASCI 290: Marine Mammal Health Enterprise (in partnership with The Marine Mammal Center)
- Guest lectures: BIO 227 (Wildlife Conservation Biology), MSCI 100 (Intro to Marine Science), MSCI 324 (Marine Mammals, Birds, and Reptiles), ASCI 312 (Production Medicine).

2008-Present **Wildlife Veterinarian, The Marine Mammal Center, San Luis Obispo Field Office, CA (contract)**
Provide emergency medical care to sick and injured stranded pinnipeds, sea otters, and cetaceans. Participate in field capture operations of sea otters, perform surgical implantation of intraperitoneal telemetry devices from mobile veterinary labs, and conduct biological sampling for disease surveillance. Perform postmortem exams and collect samples for population health investigations. Teach training classes for interns, veterinary students, and volunteers.

2006-Present **Wildlife Veterinarian, NOAA Protected Resources Division, West Coast Region (contract)**
Lead population level health investigations of endangered sea turtles and their prey on foraging grounds and nesting beaches in the Pacific/Atlantic/Caribbean. Provide field veterinary support for boat-based captures, nesting beach monitoring, and mass stranding events. Develop field methods for biological sampling of leatherback turtles (fat biopsies, ultrasonography, blood collection, skin samples). Teach multi-agency workshops on sea turtle stranding response and participate in scientific working groups addressing threats to survival. Provide veterinary expertise for permits, IACUC protocols, emergency response protocols for field captures, and best practices for safety in research.

PROFESSIONAL EXPERIENCE

2010-2018 **Shelter Veterinarian (part-time), Woods Humane Society, San Luis Obispo, CA (contract)**
Perform high-volume surgical procedures (spay/neuter, biopsy, mass removal, trauma repair, enucleation, etc.). Provide medical care, emergency response, and infectious disease management for small animals in a shelter setting.

2015 **Supervisor: Marine Mammal Field Stabilization, Oiled Wildlife Care Network, Davis, CA (contract)**
Staff position in group supervisory role during Refugio Incident. Led field stabilization efforts for live oiled marine mammals recovered from the spill zone including medical evaluation, clinical care, and evidence sampling. Trained staff and volunteers to assist with stabilization procedures following chain of custody protocols.

2007-2011 **Wildlife Veterinarian, NOAA National Marine Mammal Lab, Seattle, WA (contract)**
Field veterinarian for annual capture operations of Steller sea lions and northern fur seals on remote Alaskan island rookeries at Kodiak, Pribilof, and Aleutian Islands. Performed field anesthesia on hundreds of juvenile and adult pinnipeds, collected biological samples, and conducted postmortem exams on dead animals in the rookeries.

2009-2010 **Wildlife Veterinarian, NOAA Hawaiian Monk Seal Research Program, Honolulu, HI (contract)**
Conducted two field seasons of deworming trials on Hawaiian monk seals at a remote island rookery on Laysan Island, NW Hawaiian Islands. Trained field staff to safely capture and restrain seals, administer oral and injectable medications, collect biological samples, and perform necropsies.

2006-2008 **Wildlife Veterinarian, Moss Landing Marine Laboratories, CA (contract)**
Provided veterinary support for captures of wild harbor seals on remote island rookeries at the California Channel Islands and along California mainland coast. Performed sedation, collected blood and fat biopsies, monitored animals, and provided emergency response.

2007-2008 **Emergency Veterinarian, Sacramento Emergency Vet Clinic, Sacramento, CA**
Provided emergency and critical care to sick and injured small animals including stabilization, diagnostic imaging, anesthesia, surgical procedures, and euthanasia.

1999-2002 **Scientific Aid, California Department of Fish and Game, Office of Spill Prevention and Response, Marine Wildlife Veterinary Care and Research Center, Santa Cruz, CA**
Assisted with population health research on southern sea otters though live field captures and necropsies of dead stranded animals. Participated in oil spill response of seabirds including field search and collection, intake, stabilization, washing, and necropsy following chain-of-custody protocols.

TEACHING EXPERIENCE

2018 **Live Sea Turtle Response Lab, West Coast Regional Stranding Conference, Seattle, WA**
Led hands-on interactive lab for on live sea turtle response and stabilization for marine mammal responders.

2017 **Sea Turtle 101 Lab, Oilapalooza Conference, Oiled Wildlife Care Network, Monterey, CA**
Led hands-on interactive lab with live sea turtles for oiled wildlife responders at the Monterey Bay Aquarium.

2016 **Pacific Northwest sea turtle stranding workshop, USFWS/NOAA, Portland, OR**
Led 2-day training workshop to build capacity for sea turtle response along the west coast of US and Canada.

2016 **Basic and advanced necropsy labs, National Marine Animal Health and Stranding Meeting, Shepherdstown, WV**
Led multiple trainings on anatomy and necropsy techniques of marine turtles for stranding network.

2014 **Sea turtle necropsy workshop, NOAA, Southwest Fisheries Science Center, La Jolla, CA**
Led 3-day training workshop on sea turtle necropsy techniques for NOAA scientists and stranding network.

2014 **Sea turtle webinar, Oiled Wildlife Care Network, Davis, CA**
Developed online webinar on oiled sea turtle response in California for staff and volunteer training.

2013 **Marine wildlife anatomy lab, Moss Landing Marine Laboratories, Moss Landing, CA**
Taught comparative necropsy lab for graduate students in marine science.

2012 **Sea turtle necropsy course, Oiled Wildlife Care Network, Santa Cruz, CA**
Led sea turtle necropsy class focusing on normal anatomy and basic data collection.

2011-2016 **Comparative anatomy labs, The Marine Mammal Center, San Luis Obispo Field Office, CA**
Teach annual necropsy classes on comparative anatomy of pinnipeds and sea otters for volunteers.

2011-2015 **Sea turtle anatomy labs, West Coast Regional Stranding Network, San Pedro, CA**
Teach annual labs for sea turtle stranding response protocols and basic data collection.

2009 **Seabird lab, California Council of Wildlife Rehabilitators, Shell Beach, CA**
Taught clinical anatomy for seabird oral feeding and injections to wildlife rehabilitators.

2008 **Pinniped necropsy lab, Michigan State University, East Lansing, MI**
Led comparative necropsy lab focusing on pinniped anatomy and disease for veterinary students.

2008 **MARVET Program, Sausalito, CA**
Taught medical procedures for rehabilitated pinnipeds to international veterinarians.

2007-2008 **Marine mammal medicine, The Marine Mammal Center, Sausalito, CA**
Trained senior veterinary students during clinical rotations in marine mammal medicine and pathology.

2003-2005 **Wildlife necropsy labs, Wildlife Medicine Club, University of California, Davis, CA**
Organized and assisted with teaching wildlife necropsies for veterinary students and residents.

OIL SPILL EXPERIENCE

2015 **Refugio Incident, Oiled Wildlife Care Network, Santa Barbara/Ventura counties, CA**
OWCN staff position: Group Supervisor, Marine Mammal Field Stabilization

2012 **Platform Houchin Spill, Oiled Wildlife Care Network, Ventura, CA**
Wildlife reconnaissance of marine birds and mammals.

2007 **Cosco Busan Oil Spill, Oiled Wildlife Care Network, San Francisco Bay/Cordelia, CA**
Field search and collection, intake, stabilization, and washing of oiled seabirds.

2002 **S.S. Jacob Luckebach Oil Spill, California Department of Fish and Game, Santa Cruz, CA**
Field search and collection and stabilization of oiled seabirds.

2001 **San Mateo Mystery Spill, California Department of Fish and Game, Santa Cruz, CA**
Necropsies of dead oiled seabirds held as evidence.

1999 **Point Reyes Tarball Incident, California Department of Fish and Game, Santa Cruz, CA**
Necropsies of dead oiled seabirds held as evidence.

RESEARCH GRANTS

2018 U.S. Fish and Wildlife Service, Recovery Project Cooperative Agreement (PI), [redacted]

2018 National Fish and Wildlife Foundation, Ocean Health Initiative (PI), $[redacted]0

2010-2012 NOAA Oceans and Human Health Initiative Research Grant (co-PI), [redacted]

2008-2011 Oiled Wildlife Care Network Research Grant (co-PI), [redacted]

2005-2007 Oiled Wildlife Care Network Research Grant (co-PI), [redacted]

2004 STAR Research Fellowship, University of California, Davis (co-PI), [redacted]0

2003 Geraldine R. Dodge Foundation, Frontiers for Veterinary Medicine Research Grant (co-PI), [redacted]

SCHOLARSHIPS

2015 Humane Alliance Scholarship, Advanced surgical training, Asheville, NC

2006-2007 Theodora Peigh Dual Degree DVM/MPVM Scholarship, University of California, Davis

2005-2006 Peigh Memorial Scholarship, University of California, Davis

SELECTED PUBLICATIONS

Harris, H., M. Flint, K. Stewart, and C. Harms. 2017. Chapter 34: Field Techniques. *In* Sea Turtle Health and Rehabilitation, 1st edition (eds. Manire, Norton, Stacy, Innis, and Harms). J Ross Publishing Inc., Plantation, FL, pp. 819-852.

Deem, S. and **H. Harris**. 2017. Chapter 39: Health assessments. *In* Sea Turtle Health and Rehabilitation, 1st edition (eds. Manire, Norton, Stacy, Innis, and Harms). J. Ross Publishing Inc., Plantation, FL, pp. 945-953.

Ferguson, S., J. Wellehan, S. Frasca, C. Innis, **H. Harris,** M. Miller, E. Weber, H. Walden, E. Greiner, C. Merigo, and B. Stacy. 2016. Coccidial infection of the adrenal glands of leatherback sea turtles (*Dermochelys coriacea*). Journal of Wildlife Diseases 52(4): 874-882.

Harris, H., S. Benson, M. James, K. Martin, B. Stacy, P. Daoust, P. Rist, T. Work, G. Balazs, and J. Seminoff. 2016. Validation of ultrasound as a noninvasive tool to measure subcutaneous fat depth in leatherback sea turtles (*Dermochelys coriacea*). Journal of Zoo and Wildlife Medicine 47(1): 275-279.

Stacy, B., C. Innis, P. Daoust, J. Wyneken, M. Miller, **H. Harris**, M. James, E. Christiansen, and A. Foley. 2014. Solitary large intestinal diverticulitis in leatherback turtles (Dermochelys coriacea). Veterinary Pathology Online DOI: 10.1177/0300985814549211.

Harris, H., S. Benson, K. Gilardi, R. Poppenga, P. Dutton, T. Work, and J. Mazet. 2011. Comparative health assessment of Western Pacific leatherback turtles (*Dermochelys coriacea*) foraging off the coast of California. Journal of Wildlife Diseases 47(2):321-337.

Harris, H., P. Facemire, D. Greig, K. Colegrove, G. Ylitalo, G. Yanagida, M. Fleetwood, F. Nutter, and F. Gulland. 2011. Congenital neuroglial heterotopia in a neonatal harbor seal (*Phoca vitulina richardsi*) with evidence of recent petroleum exposure. Journal of Wildlife Diseases 47(1):246-254.

Harris, H., S. Oates, M. Staedler, M. Tinker, D. Jessup, J. Harvey, and M. Miller. 2010. Lesions associated with forced copulation of juvenile harbor seals by southern sea otters. Aquatic Mammals 36(4):331-341. DOI 10.1578/AM.36.4.2010.219

SCIENTIFIC CONFERENCE ABSTRACTS

Harris, H. 2018. Cold-stunned sea turtle response along the U.S. west coast. Sea Turtle Medicine Workshop, International Sea Turtle Symposium, Kobe, Japan, February 19-23.

Harris, H. and J. Greenman. 2016. Wildlife response and field stabilization: Refugio case study. National Marine Animal Health and Stranding Network Conference, Shepherdstown, West Virginia, Sept 6-9.

Harris, H., S. Benson, M. James, K. Martin, B. Stacy, P. Daoust, P. Rist, T. Work, G. Balazs, and J. Seminoff. 2015. Validation of ultrasound as a noninvasive tool to measure subcutaneous fat in leatherback sea turtles. Proceedings of the 46th Annual Conference of the International Association of Aquatic Animal Medicine, Chicago, Illinois, April 6-10.

Harris, H., R. LeRoux, C. Fahy, and J. Seminoff. 2015. Sea turtle necropsy workshop: Case highlights. West Coast Marine Mammal Stranding Regional Meeting, Long Beach, California, March 23-25.

Harris, H., S. Benson, S. Fire, M. Miller, B. Stacy, R. Kudela, C. Fahy, and J. Seminoff. 2014. Domoic acid in the leatherback turtle food web on critical foraging grounds in central California. California Marine Mammal Stranding Network Meeting, La Jolla, California, February 6-8.

Harris, H., S. Benson, M. Miller, S. Fire, B. Stacy, R. Kudela, C. Fahy, and J. Seminoff. 2013. Domoic acid in the leatherback turtle food web on critical foraging grounds in central California. Proceedings of the 44th Annual Conference of the International Association of Aquatic Animal Medicine, Sausalito, California, April 21-25.

Harris, H., S. Benson, M. James, K. Martin, B. Stacy, C. Innis, J. Cavin, P. Daoust, P. Rist, T. Work, G. Balazs, and J. Seminoff. 2013. Validation of ultrasonography as a noninvasive diagnostic tool to measure subcutaneous fat depth in leatherback turtles. Proceedings of the 33rd Annual Symposium on Sea Turtle Biology and Conservation. International Sea Turtle Society, Baltimore, Maryland, February 4-8.

Harris, H., S. Fire, S. Benson, C. Fahy, and J. Seminoff. 2012. Scyphozoan jellies as biological sensors for domoic acid on critical foraging grounds for the leatherback turtle. CalCOFI conference, Monterey, California, Dec 4.

Harris, H., S. Fire, S. Benson, C. Fahy, and J. Seminoff. 2012. Scyphozoan jellies as biological sensors for domoic acid on critical foraging grounds for the leatherback turtle. Gordon Research Conference on Oceans and Human Health, Biddeford, Maine, June 2-8.

Harris, H., S. Benson, G. Ylitalo, S. Fire, R. Poppenga, C. Fahy, and J. Seminoff. 2011. Evaluation of scyphozoan jellyfish as biological indicators for coastal marine pollution and leatherback turtle health. Proceedings of the 31st Annual Symposium on Sea Turtle Biology and Conservation. International Sea Turtle Society, San Diego, California, April 10-16.

Harris, H., C. Fahy, R. LeRoux, S. Benson, E. LaCasella, S. Wilkin, P. Dutton, and J. Seminoff. 2010. Integrating health research into leatherback turtle stranding response in California. National Marine Animal Health and Stranding Network Conference, Shepherdstown, West Virginia, April 6-9.

Harris, H., S. Benson, P. Dutton, K. Gilardi, R. Poppenga, T. Work, and J. Mazet. 2009. Incorporating health studies in the conservation of western Pacific leatherback turtles. The Wildlife Society, Monterey, California, September 20-24.

Harris, H. Leatherback turtle strandings in California: What can we learn? 2009. California Regional Stranding Network Meeting. Santa Barbara Museum of Natural History, Santa Barbara, CA, March 16-18.

Harris, H., S. Benson, P. Dutton, K. Gilardi, R. Poppenga, T. Work, and J. Mazet. 2009. Comparative health assessment of Western Pacific leatherback turtles (*Dermochelys coriacea*) foraging off the coast of California, 2005-2007. Proceedings of the 29th Annual Symposium on Sea Turtle Biology and Conservation. International Sea Turtle Society, Brisbane, Australia, February 17-19.

Harris, H., S. Benson, K. Gilardi, R. Poppenga, P. Dutton, T. Work, and J. Mazet. 2008. Health assessment of foraging Pacific leatherback turtles off the coast of California. Proceedings of the 39th Annual Conference of the International Association for Aquatic Animal Medicine, Rome, Italy, May 10-14.

Harris, H., M. Miller, and P. Conrad. 2004. Aggressive interspecific sexual behavior in the southern sea otter. Student Training in Advanced Research Fellowship Seminar, University of California, Davis, CA.

Harris, H., D. Jessup, and J. Mazet. 2004. Development of a comprehensive database for health monitoring of the southern sea otter as an indicator of marine ecosystem health. Geraldine R. Dodge Foundation, Frontiers for Veterinary Medicine Conference, White Oak Conservation Center, Yulee, FL.

INVITED TALKS

Harris, H. 2017. Living dinosaurs: leatherback sea turtles along the central coast. Sharks-After-Dark lecture series, Central Coast Aquarium, Avila Beach, CA, Nov 16.

Harris, H. 2017. Marine wildlife veterinary medicine. Cal Poly Wildlife Club, San Luis Obispo, CA, Oct 12.

Harris, H. 2017. Leatherback health: a one health perspective. Moss Landing Marine Laboratories: Leatherback Conservation Day, Moss Landing, CA, Oct 13.

Harris, H. 2017. West coast sea turtle health: A conservation medicine perspective. Cal Poly Biological Sciences Seminar Series, Feb 17.

Harris, H. 2016. Integrating marine mammals at Cal Poly. Friends of the Elephant Seal, Cambria, CA, Nov 16.

Harris, H. 2016. Careers in marine wildlife health. Cal Poly Zoo and Exotics Club, San Luis Obispo, CA, Mar 3.

Harris, H. 2014. A big picture look at the biotoxin domoic acid in diverse marine food webs. Monterey Bay National Marine Sanctuary Seminar Series, Cambria, CA, May 9.

Harris, H. 2013. Leatherback health connections. The Leatherback Summit, Monterey, CA, Oct 14.

Harris, H. 2013. Dinosaurs of the ocean. Central Coast Aquarium, Avila Beach, CA, Aug 16.

Harris, H. 2013. Sea turtle population health. Moss Landing Marine Labs, Moss Landing, CA, Apr 17.

Harris, H. 2012. The health of sea turtles in California. The Marine Mammal Center, Morro Bay, CA, Dec 12.

Harris, H. 2012. California live sea turtle stranding protocol. California Marine Mammal Stranding Network Meeting, San Pedro, CA, Nov 15.

Harris, H. 2012. Sea turtle populations in California: Implications for oil spill response. Oiled Wildlife Care Network, Oilapalooza Conference, Santa Cruz, CA, Oct 27.

Harris, H. 2012. Careers in marine wildlife health. Stanford University, Department of Comparative Medicine, Pre-Vet Expo III, Palo Alto, CA, May 19.

Harris, H. 2012. Endangered western Pacific leatherback turtles: Health assessment of turtles and their prey on critical foraging grounds in central California. Morro Coast Audubon Society, Community Program. San Luis Obispo, CA, March 19.

Harris, H. 2012. Health investigations of endangered Pacific leatherback turtles and their prey on critical foraging grounds in central California. California Polytechnic State University, Biological Sciences Seminar Series, San Luis Obispo, CA, March 9.

Harris, H. 2009. Pinniped health studies: from monk seals in the tropics to fur seals in the arctic. Educational Research Update. The Marine Mammal Center, Morro Bay, CA, November 11.

Harris, H. 2009. Comparative health assessment of Western Pacific leatherback turtles foraging off the coast of California. NOAA Southwest Fisheries Science Center, Seminar Series. La Jolla, CA, April 14.

Harris, H. 2008. The role of vets in wildlife health. Marine Wildlife Lecture Series. Michigan State University, School of Veterinary Medicine, Lansing, MI, November 14.

Harris, H. 2008. California sea lions: Common clinical diseases in rehabilitation. Marine Wildlife Lecture Series, Michigan State University, School of Veterinary Medicine, East Lansing, MI, November 13.

Harris, H. 2008. Leatherback sea turtle health monitoring. Educational Research Update. The Marine Mammal Center, Sausalito, CA, May 29.

SPECIALTY TRAININGS

2016	ICS 100, 200, 700, Federal Emergency Management Agency
2014	Field Stabilization, Levels 1 and 2, Oiled Wildlife Care Network
2012	Veterinary Care of Oiled Sea Otters, Oiled Wildlife Care Network
2005	Oiled Wildlife Care, UC Davis Wildlife Health Center
2004	Dart-gun Handling, UC Davis Wildlife Health Center
2003	Wildlife Capture and Restraint, California Department of Fish and Game
2001	Advanced Supervisor for Oil Spill Response, Oiled Wildlife Care Network
2001	Wildlife Necropsy Techniques, California Department of Fish and Game
2000	Basic Supervisor for Oil Spill Response, Oiled Wildlife Care Network
1999	Small Boat Operation, California Department of Boating and Waterways
1996	Open Water SCUBA, NAUI

PROFESSIONAL SERVICE

2018	38th International Sea Turtle Symposium: Session Chair, Anatomy/Physiology/Health Session, Kobe, Japan, Feb 19-23.
2016	National Marine Animal Health and Stranding Network Conference: Steering Committee, Necropsy and Population Health subcommittees, Shepherdstown, WV, Sep 6-9.
2013	44th International Association of Aquatic Animal Medicine: Session Chair, Turtle Health and Medicine Session, Sausalito, CA, Apr 21-25.
2013	33nd International Sea Turtle Symposium: Session Chair, Anatomy/Physiology/Health Session, Baltimore, MD, Feb 3-8.
2011	31st International Sea Turtle Symposium: Sea Turtle Medicine Workshop, San Diego, CA, Apr 11.
2010-Present	Journal reviewer: Wildlife Disease Association, Endangered Species Research, Chelonian Conservation and Biology.
2005	11th Annual Wildlife Medicine Symposium, Organizer/Moderator, UC Davis, Jan 29.
2004-05	American Association of Wildlife Veterinarians: President, UC Davis Student Chapter.

PROFESSIONAL AFFILIATIONS

2017-Present	American College of Preventive Veterinary Medicine
2008-Present	International Association for Aquatic Animal Medicine
2006-Present	International Sea Turtle Society
2006-Present	American Veterinary Medical Association
2002-Present	Wildlife Disease Association

Curriculum Vitae

Michael C. Kenner

PRESENT ADDRESS: USGS Pacific Coastal and Marine Science Center
WERC Santa Cruz Field Station
2885 mission St, Santa Cruz CA 95060

EDUCATION: BS University of California, Irvine 1980 Biological Sciences

MS California State University, Hayward and Moss Landing Marine Laboratories 1988 Marine Sciences

WORK EXPERIENCE:

Current — Wildlife Biologist at USGS Santa Cruz Field Station
Duties as below

1985 to 2019 — Marine Technician, University of California Santa Cruz
Manage semi–annual long-term baseline surveys of intertidal and subtidal sites at San Nicolas Island, CA. Collect data on densities, size distributions, growth, and food habits of intertidal and kelp forest organisms. Lead or assist with field studies on kelp forest and intertidal communities. Manage annual black abalone surveys at SNI. Enter and manage data for long term projects. Write annual reports for SNI subtidal and abalone monitoring for US. Navy. Assist with capture, handling, and transport of sea otters; assist with semiannual census of California sea otters. Assist with analysis of sea otter population and habitat data. Assist with sea otter telemetry projects. Participate in sea otter carcass recovery program.

1984 – 1985 — Biological Technician, US Fish and Wildlife Service
Assist with field work on kelp forest and intertidal communities. Enter data and assist with data management. Purchase and maintain equipment for USFWS Santa Cruz field station.

1983 – 1984 — Biological Technician, California Department of Fish and Game
Assist with field collections, data entry/management, and laboratory preparation of samples for trace metal contaminants analysis for the State Mussel Watch program.

1983 — Teaching Assistant, Moss Landing Marine Lab
Marine Phycology

PUBLICATIONS AND PAPERS:

Kenner, M.C. 1987. Population ecology of Strongylocentrotus purpuratus inhabiting sublittoral coralline mats within the range of the sea otter in California. M.S. Thesis, California State University, Hayward and Moss Landing Marine Laboratories, CA, 64pp.

Bodkin, J.L. and M.C. Kenner. 1988. A preliminary report on the demography of the spiny lobster, Panulirus interruptus, at San Nicolas Island, CA Fifth Biennial Mugu Lagoon / San Nicolas Island Symposium Proceedings, Pt. Mugu, CA 1988, pp. 75-82.

Kenner, M.C. and M.T. Lares 1991. Size at first reproduction of the sea urchin Strongylocentrotus purpuratus in a central California kelp forest. Mar. Ecol. Prog. Ser. 76: 303-306.

Kenner, M.C. 1992. Population dynamics of the sea urchin Strongylocentrotus purpuratus in a central California kelp forest: recruitment, mortality, growth, and diet. Mar. Biol. 112: 107-118.

T. A. Ebert, J. C. Hernández, S. Clemente, M. P. Russell, L. V. Basch, R. A. Boolootian, P. M. Detwiler, M. C. Kenner, A. L. Lawrence, J. M. Lawrence, D. L. Leighton, J. S. Palleiro, and J. S. Pearse 2013. Half a century (1954-2009) of dissection data of sea urchins from the North American pacific coast (Mexico to Canada). Ecology 94:2109–2110.

Kenner, Michael C., James A. Estes, M. Tim Tinker, James L. Bodkin, Robert K. Cowen, Christopher Harrold, Brian B. Hatfield, Mark Novak, Andrew Rassweiler, and Daniel C. Reed 2013. A multi-decade time series of kelp forest community structure at San Nicolas Island, California (USA). Ecology 94:2654–2654

Kira A. Krumhansl, Daniel K. Okamoto, Andrew Rassweiler, Mark Novak, John J. Bolton, Kyle C. Cavanaugh, Sean D. Connell, Craig R. Johnson, Brenda Konar, Scott D. Ling, Fiorenza Micheli, Kjell M. Norderhaug, Alejandro Pérez-Matus, Isabel Sousa-Pinto, Daniel C. Reed, Anne K. Salomon, Nick T. Shears, Thomas Wernberg, Robert J. Anderson, Nevell S. Barrett, Alejandro H. Buschmann, Mark H. Carr, Jennifer E. Caselle, Sandrine Derrien-Courtel, Graham J. Edgar, Matt Edwards, James A. Estes, Claire Goodwin, Michael C. Kenner, David J. Kushner, Frithjof E. Moy, Julia Nunn, Robert S. Steneck, Julio Vásquez, Jane Watson, Jon D. Witman, and Jarrett E. K. Byrnes 2016. Global patterns of kelp forest change over the past half-century. PNAS 113: 13785-13790.

Kenner, M.C., 2016. “San Nicolas Island Kelp Forest Monitoring - First Annual Report - Fiscal Year 2015”. A report to the US Navy. University of California, Santa Cruz, CA. 61 pages

Kenner,M.C., 2016. “Kelp Forest Monitoring at Naval Base Ventura County, San Nicolas Island, CA Fall 2015 and Spring 2016 - Second Annual Report”. A report to the US Navy. University of California, Santa Cruz, CA. 68 pages.

Ebert, Thomas; Barr, Louis; Bodkin, James; Burcham, Dirk; Bureau, Dominique; Carson, Henry; Caruso, Nancy; Caselle, Jennifer; Claisse, Jeremy; Clemente, Sabrina; Davis, Katie; Detwiler, Paul; Dixon, John; Duggins, David; Engle, John; Estes, James; Groth, Scott; Grupe, Benjamin; Halmay, Peter; Hebert, Kyle; Hernández, José Carlos; Jurgens, Laura; Kalvass, Peter; Kenner, Michael; Konar, Brenda; Kushner, David; Lee, Lynn; Leighton, David; Montaño-Moctezuma, Gabriela; Munk, Eric; Olguin Espinoza, Irma; Palleiro, Julio; Parker, David; Pearse, John; Pondella, II, Daniel; Rogers-Bennett, Laura; Schroeter, Stephen; Shelton, Andrew; Sonnenholzner, Jorge; Taniguchi, Ian; VanBlaricom, Glenn; Watson, Jane; Weitzman, Benjamin; Williams, Jonathan; Yakimishyn, Jennifer; Zhang, Zane, 2018. Size, growth, and density data for shallow-water sea urchins from Mexico to the Aleutian Islands, Alaska, 1956–2016. Ecology 99(3): 761-761.

M.C. Kenner, 2018. “Kelp Forest Monitoring at Naval Base Ventura County, San Nicolas Island, CA Fall 2016 and Spring 2017 - Third Annual Report”. A report to the US Navy. University of California, Santa Cruz, CA. 81 pages.

Kenner, Michael C., and M. Tim Tinker, 2018. Stability and Change in Kelp Forest Habitats at San Nicolas Island. Western North American Naturalist 78(4).

PAPERS GIVEN:

Ecology of a cryptic population of Strongylocentrotus purpuratus inhabiting sublittoral coralline mats. 66th Annual Meeting of the Western Society of Naturalists, December 1985

Macrocystis canopy and kelp recruitment cycling at San Nicolas Island, California. 71st Annual Meeting of the Western Society of Naturalists, December 1990.

Subtidal ecosystem changes at San Nicolas Island. Michael C. Kenner and James A. Estes, California. Sixth California Islands Symposium, December 2003

San Nicolas Island Subtidal baseline Project: Over 30 years and still counting, Eighth California Islands Symposium, October 2012

Stability and change in kelp forest habitats at San Nicolas Island, Michael C. Kenner and Martin T. Tinker. Ninth California Islands Symposium, October 2016

Lesanna L Lahner DVM, MPH

PROFESSIONAL OBJECTIVE

To promote conservation and improve ecosystem and community health through exceptional veterinary medical care, research, and translational science.

EDUCATION

Doctor of Veterinary Medicine (DVM)
University of Wisconsin – Madison, WI. GPA 3.8, 2006-2011

Master of Public Health (MPH)
University of Wisconsin – Madison, WI. GPA 3.9, 2008-2010

Bachelor of the Arts (BA)
Carleton College, Northfield, MN. Biology, 2000-2004

WILDLIFE VETERINARY MEDICINE and RESEARCH EXPERIENCE

Lead Veterinarian, Interim, Minnesota Zoological Gardens, Apple Valley, MN
2017- current, full-time

- Develop, implement, and maintain cutting edge preventive medicine program for a large (5,000 + animals) and diverse collection of wildlife.
- Provide timely and appropriate veterinary medical care for sick and injured animals.
- Manage a team of veterinarians and veterinary technicians to ensure clear communication regarding animal health care to promote excellent welfare.

Execute Director and Veterinarian, SR³ Sealife Response, Rehab, and Research Seattle, WA
2016- 2018, full-time

- Overall strategic and operational responsibility for staff, programs, construction of a new facility, and execution of the mission.
- Develop core scientific and medical programs, operations, and a sustainable business plan.
- Manage field and onsite veterinary care including stranded/injured wildlife response as well as medical aspects of research programs.
- Provide emergency veterinary medical care for marine mammals and birds.
- Develop, maintain, and support a strong Board of Directors and build board involvement with strategic direction.

AWARDS & HONORS

2017 Nominated and Appointed to the AVMA Steering Committee on Human-Animal Interactions for Wildlife

2016 Nominated by peers to author the Sea Otter Medicine Chapter, CRC Marine Mammal Medicine

2015 NSF Grant recipient, Sea Star Wasting Disease, Boeing Research Award for Marine Mammal Disentanglement

2014 Boeing Research Award for Sea Star Wasting Disease Initiative

2011 Excellence in Avian Medicine and Surgery, UW-Madison

2011 Excellence in Wildlife, Exotics, & Zoo Animal Medicine, & Henry Vilas Zoological Scholarship, Connor DVM/MPH Scholarship

[redacted] [redacted] lesanna.lahner@state.mn.us

Veterinarian, Sarvey Wildlife Rehabilitation Center, Arlington, WA

2012-present, part-time

- Provide veterinary medical care, including surgery and intensive care, for a variety of native wildlife species with an emphasis on birds of prey such as bald eagles, hawks, and owls.
- Work with state and federal agencies to ensure priorities are met for wildlife recovery and rehabilitation.
- Perform necropsies and obtain information on local wildlife disease issues for surveillance of important emerging diseases such as highly pathogenic avian influenza, White Nose Syndrome, and more.

Affiliate Professor, University of Washington, Seattle WA

2015-present, part-time

- Lecture for and mentor students from a variety of programs including the MPH, MD, and PhD students associated with the Center for One Health Research and Environmental Health.

Relief Veterinarian, PAWS Wildlife Center, Seattle WA

2012-present, part-time

- Provide veterinary care, including surgery and intensive care, for a variety of native wildlife species.

Staff Veterinarian, Seattle Aquarium, Seattle, WA

2011-2016, full-time

- Develop and manage new onsite veterinary care program including preventive medicine protocols, treatment plans, medical equipment, animal husbandry, bio-security and nutrition.
- Provide routine and emergency care for marine mammals, birds, fish, and marine invertebrates.
- Create and maintain conservation medicine program that involves field and onsite wildlife health research and grant applications, publishing peer-reviewed literature, and performing translational science.
- Perform mammal and bird necropsies and provide training and oversight of fish and invertebrate necropsies.
- Oversee, teach, and train visiting veterinary students and veterinary technicians.

Part-time and Relief Veterinarian, Point Defiance Zoo and Aquarium, Tacoma, WA

2012-2015, part-time

- Provide routine and emergency veterinary care for terrestrial and marine mammals, birds, fish, and elasmobranchs.
- Provide on-call relief and assist with intensive procedures as needed.

Wildlife Epidemiologist and Veterinarian, Lincoln Park Zoo, Chicago, IL

Davee Center for Epidemiology and Endocrinology, 2011, full-time

- Developed and managed new and existing wildlife disease projects in domestic and international field settings.
- Support new and existing captive breeding and reintroduction programs.
- Provide assistance with infectious disease issues and investigate the role of disease in zoo animal health and sustainable zoo populations.

Wildlife Veterinarian, US Fish and Wildlife Service, Honolulu, HI

Palmyra Atoll Rat Eradication, February 2011-August 2011

- Coordinated and executed shorebird mitigation including capture, aviary design and construction, health monitoring, nutrition, and medical care of vulnerable shorebirds in a remote field setting.
- Monitored non-target mortalities and performed necropsies with tissue collection for analysis of anti-coagulants, contaminants, and histological examination.

Wildlife Biologist, USGS National Wildlife Health Center, Madison, Wisconsin

Research Branch under Drs. Franson and Sileo, January 2007-May 2011, part-time

- Designed and participated in research studies including metallic copper toxicity in raptors as an alternative to lead ammunition, avian influenza, lead toxicity, and West Nile virus.
- Trained staff in, and performed, wildlife capture and handling, sample collection, euthanasia, necropsy, and bio-safety level (BSL) 3 laboratory procedures.

UW-Madison, School of Population Health, Master of Public Health Thesis

Master of Public Health Student, January 2009-June 2010

- Acted as lead coordinator to investigate the spatial and temporal dynamics of the sustained high incidence of human West Nile Virus (WNV) infections in North Dakota.
- Collected and analyzed data on human WNV infections and environmental and social variables using geographic information systems (GIS) and Bayesian (WinBUGS) statistics.

National Wildlife Health Center Honolulu Field Station, Honolulu, Hawai'i

Research Assistant to Dr. Thierry Work, Summer 2008

- Performed chelonian, avian, and fish necropsies and fieldwork including coral health transects and ecological field studies.
- Designed and executed a repeatable experimental model for the assessment of disease in coral species under natural or artificial conditions.

University of Wisconsin –Madison, Large Animal Teaching Hospital

Veterinary medical technician, 2005-2007

- Performed physical examinations, administered medications and treatments, and placed intravenous catheters on large animals including horses, cattle, and camelids.
- Assisted with the care of non-ambulatory large animals including transport, sling placement, float tank usage, and emergency stabilization of critically ill patients.

Minnesota Wildlife Rehabilitation Center, Roseville, Minnesota

Wildlife Rehabilitation Intern, Spring/Summer 2005

- Assisted veterinarians with the examination, stabilization, and treatment of various wildlife species.
- Supervised and trained volunteers, organized supplies and fundraising events.

The Raptor Center, University of Minnesota, St. Paul, Minnesota

Raptor Handler, Veterinary Assist, and Education Volunteer, 1995-2002

- Assisted veterinarians with the examination and treatment of various birds of prey.
- Fed and medicated birds and maintained enclosures.
- Presented educational seminars to children and adults on raptor conservation.

The Wildlife Rehabilitation Center, University of Minnesota, St. Paul, Minnesota

Bat and Avian Caretaker, 1997-2000

- Assisted veterinarians with the examination and treatment of various wildlife species with an emphasis on bats and waterfowl species.
- Fed and medicated bats and birds and maintained enclosures.
- Trained new volunteers in safe handling of bats and various aquatic birds.

SKILLS

Exceptional interpersonal and communication skills

Strong technical and scientific background

Highly productive & hardworking

Proven ability to work remotely & independently

Competent and safe animal handler including wildlife and large animals

Fluent in Spanish & basic skills in Japanese

Trained in SAS, GIS, and WinBUGs statistical software

PUBLICATIONS

Hewson I, JB Button, BM Gudenkauf, B Miner, AL Newton, JK Gaydos, J Wynne, CL Groves, G Hendler, M Murray, S Fradkin, M Breitbart, E Fahsbender, KD Lafferty, AM Kilpatrick, CM Miner, P Raimondi, **LL Lahner**, CS Friedman, S Daniels, M Haulena, J Marliave, CA Burge, ME Eisenlord, and CD Harvell. 2014. Densovirus associated with sea-star wasting disease and mass mortality. Proceedings of the National Academy of Sciences.

Lahner LL, JC Franson, CU Meteyer, and BA Rattner. 2011. Absence of toxicity of copper pellets simulating oral exposure to bullet and shot fragments in American kestrels (Falco sparverius). Archives of Environmental Contamination and Toxicology.

Mans C, D Guzman Sanchez-Migallon, **LL Lahner**, J Paul-Murphy, and KK Sladky. 2011. Intranasal midazolam causes conscious sedation in Hispaniolan Amazon parrots (Amazona ventralis). Journal of Avian Medicine and Surgery.

Mans C, **LL Lahner**, SM Johnson, and KK Sladky. 2012. Antinociceptive efficacy of buprenorphine and hydromorphone in red-eared slider turtles (Trachemys scripta elegans). Journal of Zoo and Wildlife Medicine.

Lahner LL and Franson JC. Lead Poisoning in Wild Birds. USGS Fact Sheet. November, 2009. http://www.nwhc.usgs.gov/publications/fact_sheets/pdfs/lead_poisoning_wild_birds_2009.pdf

CONFERENCE ABSTRACTS

Lahner LL, JH Breeden, R Breeden, and A. Wegmann. The captive care and treatment of brodifacoum toxicosis in a vulnerable shorebird, the Bristle-thighed curlew (Numenius tahitiensis), during a rat eradication project, Palymyra Atoll, 2011. Accepted for presentation at the American Association of Zoo Veterinarians. Portland, OR. September, 2015.

Lahner LL, S Wahlstrom, A Newton, M Haulena, M Garner and C Mah. Efficacy of intracoelomic enrofloxacin for the treatment of sea star wasting disease in four species of captive asteroidea. Accepted for presentation at the American Association of Zoo Veterinarians. Portland, OR. September, 2015.

Lahner LL, M Murray, J Rasmussen, E Hofmeister, S Wahlstrom, K Roehl, G Sturgeon, M Garner, T Belting, and S Perry. Safety and antibody response to West Nile Virus vaccination in captive sea otters (Enhydra lutris). International Association of Aquatic Animal Medicine, Chicago, IL. April 2015.

Wahlstrom S, **LL Lahner**, A Newton, M Garner, and C Mah. Efficacy of intracoelomic enrofloxacin for the treatment of sea star wasting disease in four species of captive asteroidea. International Association of Aquatic Animal Medicine, Chicago, IL. April 2015.

Lahner LL, A Newton, M Haulena, M Garner, I Hewson. A multidisciplinary investigation of sea star wasting disease. International Association of Aquatic Animal Medicine, Gold Coast, Australia. April 2014.

Lahner LL, T Belting, M Murray. Urolithiasis and perivulvar dermatitis in captive sea otters (Enhydra lutris). Sea Otter Conservation Workshop, Seattle, WA. March 2013.

Lahner LL, S Larson, SM Boutelle. An evaluation of deslorelin implants for contraception in captive sea otters (Enhydra lutris) using fecal gonadal hormone. American Association of Zoo Veterinarians. Oakland, CA. October, 2012.

Lahner LL, C Mans, and KK Sladky. Comparison of route and location of administration for induction of injectable anesthesia in red-eared slider turtles (Trachemys scripta elegans). American Association of Zoo Veterinarians. Kansas City, MO. October, 2011

Lahner LL, Work TH, and Eismueller RL. Health of a Common Scleractinian Coral (Montipora capitata) Under Artificial and Controlled Conditions. European Wildlife Disease Association Student Conference, Veyrier-du-Lac, France. March, 2009

PROFESSIONAL MEMBERSHIPS

- American Association of Zoo Veterinarians (AAZV), Associate Member, 2011-present
- International Association for Aquatic Animal Medicine (IAAAM), 2013-present
- Wildlife Disease Association (WDA), Member, 2011-present
- American Veterinary Medical Assocation (AVMA), Member, 2006 to present
- Association of Zoos and Aquariums (AZA), Professional Affiliate, 2011-2016
- National Wildlife Rehabilitation Association (NWRA), 2016-present
- Wisconsin and Illinois Veterinary Medical Associations, 2010-2012
- Washington State Veterinary Medical Association, 2012-present

PROFESSIONAL CERTIFICATIONS

- Certified Veterinary Acupuncturist (CVA) for large, small and exotic animals.
  The Chi Institute of Traditional Chinese Veterinary Medicine, Reddick, FL. 2009
- USDA Licensed Veterinarian, 2013-present

MICHAEL J. MURRAY DVM

Curriculum Vitae

[redacted])
mmurray@mbayaq.org

EDUCATION

Doctor of Veterinary Medicine (DVM), Purdue University, 1977
Pre-Veterinary Curriculum, Purdue University, 1971-1973

Professional Licenses

Veterinary Medicine, Dentistry, and Surgery, California
Veterinary Medicine, Dentistry, and Surgery, Indiana
USDA Accredited Veterinarian

Professional Affiliations

Research Associate, University of California, Santa Cruz
Advisor, Accreditation Commission, Association of Zoos and Aquariums
Editorial Review Board, Journal of Zoo and Wildlife Medicine
Editorial Review Board, Journal of Avian Medicine and Surgery
Editorial Review Board, Seminars in Avian & Exotic Pet Medicine, WB Saunders, Co., 2000-2012
Editorial Review Board, Compendium on Continuing Education for the Practicing Veterinarian, 1999-2007
Member, Animal Health Committee, Association of Zoos and Aquariums, 2005-2011
Associate Editor, Journal of Avian Medicine and Surgery, 1995 - 1999
Session Chair, Small Mammal Program, North American Veterinary Conference, 2003 – 2006

HONORS AND AWARDS

US Army Health Professions Scholarship, 1973-1977
Phi Zeta, Veterinary Scholastic Honor Society
US Army Medical Department Veterinary Officer's Course Commandant's List, 1977
US Army Commendation Medal, 1979, 1980
US Army Meritorious Service Medal, 1983
Monterey County Society for the Prevention of Animals Humanitarian of the Year, 1986, 2001
Speaker of the Year for the Exotic Animal Program, North American Veterinary Conference, 2001
Exotic DVM of the Year, 2002
Association of Zoos & Aquariums, Inspector of the Year, 2011
Text and Academic Authors Association, Texty Excellence Award, 2012
Association of Zoos & Aquariums, Outstanding Service Award, 2012

EXPERIENCE

Monterey Bay Aquarium
Director of Veterinary Services
1988 to present
Duties include provision of on-site and on-call veterinary support for all exhibit animals, including exhibit Southern sea otters. Additional responsibilities include veterinary support for orphaned and injured wild Southern sea otters, which may be admitted by the Monterey Bay Aquarium's Sea Otter Research and Conservation Program. Additionally, liaison is maintained with, and veterinary medical and surgical

support provided to a number of outside private and government agencies involved in management and research associated with the Southern sea otter. This position became a full-time position on 1 April 2004.

Avian & Exotic Clinic of the Monterey Peninsula
Founder and Staff Veterinarian
1989 to 2004
A private veterinary practice with a caseload consisting exclusively of avian and exotic patients; approximately 40% avian, 20% reptile, 30% small mammal (not dog/cat), and 10% others (fish, invertebrates) averaging 80-100 cases per week.

Antech Diagnostics
Avian & Exotics Consultant
1999 to 2010
One of several veterinarians contracted with a private veterinary diagnostic laboratory as avian and exotic animal clinical consultants. As such, provides telephonic consultation to lab client veterinarians requesting assistance in case management or interpretation of clinical laboratory data.

Ventana Wilderness Society
Consulting Veterinarian
1986 to present
Responsibilities include providing medical and surgical care for a non-profit organization, which is involved in the translocation and re-introduction of endangered species. Thus far, the program has successfully re-established breeding pairs of bald eagles in central California and is currently one of the three field sites for re-introduction of the California condor.

Monterey County SPCA Wildlife Rehabilitation Center
Staff Veterinarian
1981 to 2004
Responsible for the provision of medical and surgical care for injured and orphaned native species of birds, mammals and reptiles.

Santa Cruz Predatory Bird Group
Consulting Veterinarian
1989-1993
Provided on-call and on-site support for the University of California at Santa Cruz project responsible for the monitoring, nest management, hack site manipulation, and cross fostering of peregrine falcons. Project discontinued as the mandated number of successful breeding pairs had been established.

Coast Veterinary Hospital
Associate Veterinarian
1983-1989
Duties included all aspects of veterinary medicine, dentistry, and surgery in an American Animal Hospital Association accredited companion animal hospital. Resigned to found the Avian & Exotic Clinic of the Monterey Peninsula.

US Army Veterinary Corps
Veterinary Officer, Captain
1977-1983
Responsible for personnel management, food hygiene and quality assurance, military working dog health, and zoonoses control on military installations. Duty assignments included Los Angeles, CA; Ft Ord, CA, and 106th Medical Detachment, Taegu, Republic of Korea. Established a program for the monitoring of diseases in wildlife populations on military installations controlled by Ft. Ord.

PROFESSIONAL AFFILIATIONS

American Veterinary Medical Association

Monterey Bay Area Veterinary Medical Association
President, 1991-1992
Association of Avian Veterinarians
Director, 1992-1995
American Association of Zoo Veterinarians
Association of Reptile and Amphibian Veterinarians
International Association of Aquatic Animal Medicine
Association of Zoos & Aquariums
Wildlife Disease Association

PUBLICATIONS, Primary Author

"Veterinary Medicine and Sea Otter Conservation". In Sea Otter Conservation, Larson SE, Bodkin JL, VanBlaricom GR (eds), Academic Press, San Diego, CA, 2015, pp 160-197.

"Euthanasia" In Invertebrate Medicine, 2nd Ed, Lewbart, GR (ed), Wiley-Blackwell, Ames, IA, 2012, pp 441-443.

"Endoscopy in Sharks" Veterinary Clinics North America Exotic Animal Practice 13(2):301-313, 2010

"Invertebrates" In Guidelines for Euthanasia of Nondomestic Animals, American Association of Zoo Veterinarians, 2006, pp 25-27.

"Sea Otters" In Guidelines for Euthanasia of Nondomestic Animals, American Association of Zoo Veterinarians, 2006, pp 75-77.

"Euthanasia" In Invertebrate Medicine, Lewbart, GA, Blackwell Publishing, Ames, IA, 2006, pp 303-304.

"Pneumonia and Lower Respiratory Tract Disease". In Reptile Medicine and Surgery, 2nd Ed, Mader, DR (ed), Saunders, Elsevier, St. Louis, 2006, pp 865-877.

"Aural Abscesses". In Reptile Medicine and Surgery, 2nd Ed, Mader, DR (ed), Saunders, Elsevier, St. Louis, 2006, pp 742-746.

"Cardiology". In Reptile Medicine and Surgery, 2nd Ed, Mader, DR (ed), Saunders, Elsevier, St. Louis, 2006, pp 181-195.

"Cardiopulmonary Anatomy and Physiology". In Reptile Medicine and Surgery, 2nd Ed, Mader, DR (ed), Saunders, Elsevier, St. Louis, 2006, pp 124-134.

"Reptilian Blood Sampling and Artifact Considerations" In Laboratory Medicine Avian and Exotic Pets, Alan Fudge, editor. WB Saunders Co, Philadelphia, 2000, pp 185-192.

"Rabbit and Ferret Sampling and Artifact Considerations" In Laboratory Medicine Avian and Exotic Pets, Alan Fudge, editor. WB Saunders Co, Philadelphia, 2000, pp 265-268.

"Endoscopic Surgery". Co-editor with Michael Taylor; Seminars in Avian and Exotic Pet Medicine, WB Saunders Co, Philadelphia, 8(3), 1999.

"Avian Renal Disease: Endoscopic Applications" Co-author with Michael Taylor; Seminars in Avian and Exotic Pet Medicine, WB Saunders Co, Philadelphia. 8(3):115-121, 1999.

"Endoscopic Examination and Therapy of the Avian Gastrointestinal Tract". Co-author with Michael Taylor; Seminars in Avian and Exotic Pet Medicine, WB Saunders Co, Philadelphia. 8(3):110-114, 1999.

“Highlights and Horizons: Exotic Animal Medicine” Compendium on Continuing Education for the Practicing Veterinarian, Trenton, NJ. 21(3):194-195/266, 1999.

“Endoscopy in Birds, Reptiles, Amphibians and Fish” Co-author with Bernd Schildger and Michael Taylor. Endo-Press, Tuttlingen, Germany. 1999.

“Diagnostic Techniques in Avian Medicine” Seminars in Avian and Exotic Pet Medicine, WB Saunders Co, Philadelphia. 6(2):48-54, 1997.

“Cardiology and Circulation” In <u>Reptile Medicine and Surgery</u>, Douglas Mader, editor. WB Saunders Co, Philadelphia, 1996, pp 95-104.

“Aural Abscesses” ” In <u>Reptile Medicine and Surgery</u>, Douglas Mader, editor. WB Saunders Co, Philadelphia, 1996, pp 349-352.

“Pneumonia and Normal Respiratory Function” ” In <u>Reptile Medicine and Surgery</u>, Douglas Mader, editor. WB Saunders Co, Philadelphia, 1996, pp 396-405.

“Soft Tissue Surgery”, editor. Seminars in Avian and Exotic Pet Medicine, WB Saunders Co, Philadelphia, 2(2), 1993.

PUBLICATIONS, co-author

Shapiro K, Miller MA, Packham AE, Aguilar B, Conrad PA, VanWormer E, **Murray MJ**, Dual congenital transmission of *Toxoplasma gondii* and *Sarcocystis neurona* in a late-term aborted pup from a chronically infected southern sea otter (*Enhydra lutris nereis*), *Parasitology* 143: 276-288, 2016.

Thometz NM, **Murray MJ**, Williams TM, Ontogeny of oxygen storage capacity and diving ability in the southern sea otter (*Enhydra lutris nereis*): costs and benefits of large lungs, *Physiological and Biochemical Zoology* 88(3):311-27, 2015.

Hewson I, Button JB, Gudenkauf BM, Miner B, **Murray M**, et al, “Densovirus associated with sea-star wasting disease and mass mortality, *Proceedings of the National Academy of Science USA*, 111(48): 17278-83, 2014.

Tuomi PA, **Murray MJ**, Garner MM, Goertz CEC, et al, “Novel poxvirus infection in northern and southern sea otters (*Enhydra lutris kenyoni* and *Enhydra lutris nereis*), Alaska and California, USA. *Journal of Wildlife Diseases* 50(3):607-615, 2014.

Li Z-N, Ip HS, Trost JF, White CL, **Murray MJ**, Carney PJ, et al. Serologic evidence of influenza A(H1N1)pdm09 virus in northern sea otters [letter]. Emerg Infect Dis [Internet]. 2014 May. http://dx.doi.org/10.3201/eid2005.131890

Bonar CJ, Garner MM, Weber ES III, Keller CJ, **Murray MJ**, Adams LM, Frasca Jr S, “Pathologic findings in weedy (*Phyllopteryx taeniolatus*) and leafy (*Phycodurus eques*) seadragons”. *Veterinary Pathology* 50(3): 368-376, 2013.

Rankin KA, Alroy KA, Kudela RM, Oates SC, **Murray MJ**, Miller MA, “Treatment of cyanobacterial (microcystin) toxicosis using oral cholestyramine: case report of a dog from Montana”. *Toxins* 2013(5):1051-1063, 2013.

Tyrrell LP, Newsome SD, Fogel ML, Viens M, Bowden R, and **Murray MJ**, “Vibrissae growth rates and trophic discrimination factors in captive southern sea otters (*Enhydra lutris nereis*)”. *Journal of Mammalogy* 94(2): 331-338, 2013.

Jessup DA, Yeates LC, Toy-Choutka S, Casper D, **Murray MJ**, Ziccardi MH. "Washing oiled sea otters". *Wildlife Society Bulletin* 36(1):6-15, 2012.

Bowen L, Miles AK, **Murray M**, et al. "Gene transcription in sea otters (*Enhydra lutris*); development of a diagnostic tool for sea otter and ecosystem health". *Molecular Ecology Resources* 12:67-74, 2012.

Bullard SA, Ruiz CF, McElwain A, **Murray MJ**, Borucinska JD, Benz, GW. "*Huffmanela CF carcharhini* (Nematoda: Trichosomoididae: Huffmanelinae) from skin of a sandbar shark, *Carcharhinus plumbeus*, in the Pacific Ocean." *Journal of Parasitology* 98(2):333-340, 2012.

Miles AK, Bowen L, Ballachey B, Bodkin JL, **Murray M**, Estes JL, Keister RA, Stott JL. "Variations of transcript profiles between sea otters *Enhydra lutris* from Prince William Sound, Alaska, and clinically normal reference otters". *Marine Ecology Progress Series* 451:201-212, 2012.

Brownstein D, Miller MA, Oates SC, Byrne BA, Jang S, **Murray MJ**, Gill VA, Jessup DA. "Antimicrobial susceptibility of bacterial isolates from sea otters (*Enhydra lutris*)". *Journal of Wildlife Diseases* 47(2):278-292, 2011.

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Miller, M. A., P. Crosbie, K. Sverlow, K. Hanni, B. Barr, N. Kock, **M. Murray**, L. Lowenstine and P. Conrad. "Isolation and characterization of *Sarcocystis* from brain tissue of a free-living southern sea otter (*Enhydra lutris nereis*) with fatal meningoencephalitis." *Parasitology Research,* 87(3):252-257. 2001.

Murray, M.J. and A. Johnson. "The use of the drug combination medetomidine/butorphanol as an analgesic sedative in the southern sea otter." Oiled Wildlife Care Network Research Symposium, Sacramento, California. May 4, 2001

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Lander, ME, Westgate, AJ, Bonde, RK, **Murray, MJ**. "Tagging and Tracking" in CRC Handbook of Marine Mammal Medicine, 2nd Ed, Dierauf, LA and Gulland FMD (eds). CRC Press, Boca Raton, FL, 2001, pp 851-880.

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Miller, MA, Crosbie, PR, Gardner, IA, Barr, BC, Lowenstine, LJ, Gulland, FM, **Murray, M**, Jessup, D, Conrad, PA. "An update on protozoal brain infections in harbor seals (Phoca vitulina richardsi) and southern sea otters (Enhydra lutris nereis) in California. 13th Joint US-Russia Sea Otter Workshop, Monterey, CA. November, 2000.

Staedler M, Johnson AB, Hymer JA, **Murray MJ**: The Monterey Bay Aquarium's sea otter research and conservation program; 1984-1998. Sea Otter in Zoos and Aquariums Consortium, Seattle, WA, 1999.

Sousa M, Giles A, Jeffries M, **Murray MJ**: Living on the edge: the challenges of elevated coliform bacteria levels in a "living" exhibit. International Marine Animal Trainers Association Annual Conference, Albufeira, Portugal, 1998.

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(a) Academic training:

• UNH	Wildlife Management	B.S.	1984
• UNH	Animal Science (Wildlife Emphasis)	M.S.	1990
• UC Davis	Veterinary Medicine	D.V.M.	1994
• North Carolina State	Medicine and Surgery	Internship	1995
• UC Davis	Anatomic Pathology	Residency	1996
• UC Davis	Anatomic Pathology	Instructorship	1998
• UC Davis	Comparative Pathology	Ph.D.	2002

(b) Employment:

1999-Present: WILDLIFE VETERINARIAN SPECIALIST/ PATHOLOGIST. **Marine Wildlife Veterinary Care and Research Center, California Department of Fish and Wildlife, Office of Spill Prevention and Response, Santa Cruz, CA 95060.** Oversee statewide marine wildlife necropsy program. Served as facility director 2010-2011. Provide expertise for forensic cases, oil spill & outbreak investigation, policy planning & program development. Conduct complex environmental health research, present findings and prepare and submit scientific publications & grant proposals. Negotiate and administer contracts. Train and oversee laboratory staff, visiting scientists and graduate students. Maintain non-salaried staff appointment at UCD and oversee UCD-based grants. Represent CDFW in official capacity to facilitate interactions with other agencies, policymakers, the public and press. Coordinate tests, complete microscopic examinations & prepare reports.

1995-1999: PATHOLOGY RESIDENT & PATHOLOGY GRADUATE ACADEMIC FELLOWSHIP. **Veterinary Medical Teaching Hospital, U.C. Davis, CA 95616.** Supervised and taught veterinary students and graduate students in the classroom and necropsy facility. Designed, funded and completed PhD dissertation research on *Toxoplasma gondii* and *Sarcocystis neurona* infections in marine species. Helped develop and validate serodiagnostic tests that are in wide use for marine wildlife. Completed advanced coursework in general pathology, immunology and cell and molecular biology. Performed necropsies on small animals, livestock, primates, reptiles, amphibians, free-living wildlife and zoo animals.

1996: PATHOLOGIST (CONTRACT). **Colorado Parks and Wildlife, Fort Collins, Colorado, 80526.** Under contract with Colorado Parks and Wildlife, evaluated formalin-fixed brain & lymph nodes collected from hunter-killed deer and elk from Colorado for lesions consistent with chronic wasting disease (CWD) and bovine tuberculosis. Compiled findings into a summary report & highlighted suspect cases for subsequent confirmatory testing. Helped prepare a summary abstract for a presentation at the annual Wildlife Disease Association meeting. Completed a residency project on chronic wasting disease in deer and elk. Trained under Dr Beth Williams from the Wyoming Veterinary Diagnostic Laboratory for CWD diagnosis.

1994-1995: SMALL ANIMAL CLINICAL MEDICINE AND SURGERY INTERN. **North Carolina State School of Veterinary Medicine. Raleigh-Durham North Carolina 27607.** Responsible for clinical case management, client communication, off-hours emergency duty & veterinary student supervision & training. Specialty training through clinical rotations in Emergency Medicine, Soft Tissue Surgery, Orthopedics, Radiology, Cardiology, Neurology, Dermatology, Oncology, Critical Care & Shelter Medicine. Responsible for providing critical care for all hospitalized animals during off hours. Interacted with referring veterinarians & clients. Fielded calls & questions from the general public and other institutions. Completed research on the disease Rocky Mountain Spotted Fever, & presented findings to NCSU faculty, staff & students.

(c) Specialized training:

- 2017: 24 h HAZWOPER, ICS 100, ICS 200 renewal, core OWCN training
- 2017: Participated in meeting with OWCN to review sea otter spill response protocols
- 2017: Editorial review of sea otter necropsy protocols/forms to facilitate spill response
- 2017: California Veterinary Medical Reserve Corps (CAVMRC) training/ certification
- 2014: Introduction to Forensics: New Mexico Veterinary Diagnostic Laboratory
- 2014: Introduction to Animal Restraint, CDFW-WIL
- 2009: CYANOHABS: 2 day course on cyanobacterial ID, toxin detection and water quality
- 2008: General Pathology-5 day intensive review of gross pathology conducted by the Armed Forces Institute of Pathology (AFIP) and the Charles Louis Davis (CL Davis) Foundation
- 2008: Descriptive Pathology-5 day intensive review of histopathology, cytology, electron microscopy immunohistochemistry and gross pathology conducted by AFIP and CL Davis
- 2005 and 2009: Preparing for and surviving court testimony, CDFW
- 1991 and 2000: Introductory and Advanced Foreign Animal Disease Diagnostic Training: USDA-APHIS Foreign Animal Disease Diagnostic Laboratory, Plum Island, New York
- 1997 & 2000: Introduction to Wildlife Forensics-R. Stroud, National Wildlife Forensic Lab.
- 1996-1997: Contract Pathologist, Colorado Division of Wildlife-Interpreted slides prepared from deer and elk for lesions consistent with chronic wasting disease and tuberculosis. Trained by Dr Beth Williams.
- Veterinary accreditation training, ACVP Board-eligible, DEA certification and licensure, media response training (UC Davis), basic chemical restraint for wildlife, basic hunter safety training, first aid, CPR.

(d) Service Appointments:

• UC Davis Wildlife Health Center	Senior Staff (NSR)	2011-Present
• The Marine Mammal Center, Marin, CA	Science Advisory Panel	2011-Present
• California Department of Fish and Wildlife	Veterinarian	1999-Present
• UC Davis Wildlife Health Center	Staff Vet./Student	1999-2004
• UCD Dept. of Pathol., Microbiol. & Immunol.	Instructor	1997-1999
• Vet. Pathol., J Wildl. Dis., Dis. Aquat. Org.	Invited editor	Ongoing

(e) Honors, awards and accomplishments:

- <u>2018: Recipient, CDFW 2018 Group Employee Excellence Award for Partnership</u> as a member of the OSPR Marine Wildlife Veterinary Care and Research Center Team
- 2018: Invited Speaker, Stanford University Medical School, Palo Alto, CA: Land-sea pollution
- 2018: Invited speaker, CL Davis Pathology Session at International Association for Aquatic Animal medicine meeting, Long Beach, CA-Coccidioidomycosis (Valley fever)

- 2018: Presenter, International Association for Aquatic Animal medicine meeting, Long Beach, CA-15 year sea otter pathology and risk factor study
- <u>2017: Plenary Speaker-CDFW Science Symposium</u>
- 2017: Invited Speaker and Panelist, UC Davis One Health Symposium
- 2017: Invited Speaker, Stanford University Medical School, Palo Alto, CA: Biological pollution
- <u>2016: Recipient, Individual award for scientific excellence, CDFW</u>
- <u>2016: Nominee-CDFW group excellence award for response effort during Refugio Oil Spill</u>
- 2016: Linda Munson Award-Provided mentorship and support for recipient of best student-led wildlife pathology manuscript award in Journal of Wildlife Disease and Journal of Zoo and Wildlife Medicine for 2016. Another student mentee was also a finalist.
- 2016: Invited Speaker, Wetlab Instructor-NOAA National Marine Mammal Stranding Meeting
- 2016: Featured Scientist-"Heirs to our Oceans" documentary series
- 2016: Invited Speaker-Western Section of the Wildlife Society
- 2015: Research findings stimulated creation of bill for California statewide cyanotoxin monitoring program (sponsored by Senator Bill Monning and Assembly Members Mark Stone and Luis Allejo)
- 2015: Invited Speaker-*Toxoplasma*-Stanford University Medical School, Palo Alto, CA
- 2015: Invited Speaker-Cyanotoxin Summit and Statewide Webinar-CDPH, Richmond, CA
- 2015: Invited Speaker-OWCN Science Symposium, UCD School of Veterinary Medicine
- 2014 Invited Speaker-Wildlife Disease Association, New Mexico
- 2014: Cover article-May, 2014 issue of PLoS Neglected Tropical Diseases
- 2014: Invited Speaker (*Toxoplasma*)-Zoobiquity Conference, Stanford Medical School
- 2013: Invited external reviewer-Surface Water Ambient Monitoring Program (SWAMP) Monitoring Plan for Cyanotoxins in Lakes/Reservoirs and Coastal Wetlands, CA,
- 2013: Keynote Speaker-Pathology Special Session-IAAAM, Marin, CA
- 2012: Invited speaker-California Cooperative Oceanic Fisheries Investigations (CalCOFI) "Harmful Algal Blooms in the California Current", Asilomar, CA
- 2012: Invited Speaker-SWRCB cyanotoxin workshop, Oakland, CA
- 2012: Research findings on land-sea flow of freshwater cyanotoxins helped prompt consideration of Pinto Lake as a site for focused remediation by the United States Environmental Protection Agency
- 2012: Invited Speaker/Panelist-AAAS Special Session-Swimming in Sick Seas, Vancouver
- 2012: Ocean Ecosystem Workgroup Member-California Water Quality Monitoring Council
- 2012: Appointed to Scientific Advisory Panel, The Marine Mammal Center, Marin, CA
- 2011: Appointed to Senior Scientific Staff-Wildlife Health Center, UCD School of Vet. Med.
- 2011: Research findings prompted declaration of total daily maximum loads (TMDLs) for microcystin discharge at Pinto Lake by Central Coast Regional Water Control Board
- 2011: Invited Speaker-Workshop on Cyanobacteria and Human Health: Merging Ecology, Epidemiology and Neurologic Disorders. Bowdoin College, Maine
- 2011: Cover article, Spring 2011 issue of Journal of Wildlife Disease
- 2010: Most cited manuscript: 2007-2010. International Journal for Parasitology
- 2009: Invited speaker-Fall, 2009 American College of Veterinary Pathology
- 2009: Invited speaker-Fall, 2009 The Wildlife Society
- 2008: Cover article, fall, 2008 issue of International Journal of Parasitology
- 2006: Research findings helped stimulate passage of CA Assembly Bill 2485 (enhanced enforcement potential for pollution crimes against mammals in California)
- 2002: Research Fellow-Morris Animal Foundation

- 2002: Best Manuscript Award-American College of Zoological Medicine
- 2001: Graduate Student Research Award-Wildlife Disease Association
- 1998: Research Fellow-Lindbergh Foundation
- 1998: Wildlife Disease Association Scholarship
- 1997: C.L. Davis DVM Foundation-Student Scholarship Award in Pathology
- 1994: Eirene Ritchie-Hill Memorial Scholarship for Wildlife Health
- 1994: Wilds Award for Achievement in Academics and Research
- 1994: Merck Veterinary Manual Achievement Award

(f) Press interactions:

Research efforts highlighted in:

Newspapers: Los Angeles Times, New York Times, Wall Street Journal, San Francisco Chronicle, Sacramento Bee, Chicago Tribune, San Jose Mercury News, Monterey Herald, local/ regional papers

Magazines and periodicals: National Geographic, Scientific American, JAVMA, JVDI, Discover Magazine, New Scientist, Ladies Home Journal, Surfrider Magazine, Morris Animal Foundation News.

Radio/ television: PBS, Discovery Channel, National Geographic (evening news and Earth Pulse), QUEST (KQED). NPR (Todd Mundt Show), Earthwatch Radio, numerous regional and local programs

(g) Student mentorship:

Postdoctoral:

UCSF: T. Fei Fan Ng
U. WY: E. Gagne

PhD:

UCD: C. Johnson, W. A. Miller, D. Rejmanek, H. Dabritz, K. Wainwright, K. Counihan-Edgar, E. VanWormer, J. Hogan, R. Stoddard, K. Hanni, S. Carrasco, D. Imai, A. Schriever, T. Burgess, M. Moriarty, R. Pesapane, R., P. Sebastian, R. Bong, A. Guimera
UCSC: C. Gibble
Stanford: R. Grewelle
University of Alberta: K. Shanebeck

MS/MPVM:

UCD: K. Shapiro, L. Godoy
UCSC: F. Batac
CSU-MLML: E. McHuron, K. Mayer
CSU-MB: M. Daniels
Tufts: L. de Whit
Royal Veterinary College, London: A. Coup
U. Hanover (Germany): K. Shanebeck
U. Wyoming: N. Carter

DVM:

UCD: H. Harris, C. Stavely, A. Fisher, A. Parker, A. Capuano
U. Washington: A. Schneider

Cornell: S. Huckabone
Tufts: K. Alroy
University of Liverpool: G. Bartlett
The Ohio State University: C. Shockling-Dent

Undergraduate:
UCSC: S. Chinn
UCD: N. Javeed
U. Northern Florida: A. Brown

Senior Veterinary Students:
Initiated development of a CDFW/UC Davis wildlife veterinary externship/training program with Dr Jonna Mazet, the Director of the UC Davis Wildlife Health Center around 2000. To date, we have co-mentored >50 senior vet externs as part of an 20 year collaboration between CDFW-WIL, CDFW-OSPR, and UCD. Several of our past externs are now nationally and internationally recognized wildlife veterinarians.

(h) Manuscripts, book chapters, articles and other products:

(In review) Burgess TL, Tinker MT, **Miller MA**, Smith WA, Bodkin JL, Murray MJ, Nichol LM, Saarinen JM, Larson S, Tomoleoni JA, Conrad PA, Johnson CK. Spatial epidemiological patterns reveal mechanisms of land-sea transmission for *Sarcocystis neurona* in a coastal marine mammal. Nature Scientific Reports.

(In review) **Miller MA**, Duignan P, Dodd E, Batac F, Staedler M, Tinker MT, Murray M, Henkel L, Gardiner C. Emergence of a zoonotic pathogen in a coastal marine sentinel: *Capillaria hepatica* (syn*. Calodium hepaticum*)-associated hepatitis in southern sea otters (*Enhydra lutris neries*)*.* J Wildl Dis.

(In press) Shockling Dent CE, **Miller MA**, Batac FI, Dodd E, Smith W, Pesapane R, Foley J. Pathology and epidemiology of nasopulmonary acariasis (*Halarachne* sp.) in southern sea otters (*Enhydra lutris nereis)*. IJP: PAW.

2019 Volokhov DV, Batac FI, Gao Y, **Miller MA,** Chizhikov VE. *Mycoplasma enhydrae* sp. nov. isolated from California sea otters *(Enhydra lutris nereis).* Int. J Syst Evolut Microbio. 69: 363-370, doi: 10.1099/ijsem.0.003144.

2018 Pesapane R, Dodd E, Javeed N, **Miller MA**, Foley J. Molecular characterization and prevalence of *Halarachne halichoeri* in threatened southern sea otters (*Enhydra lutris nereis*)*.* IJP:PAW. https://doi.org/10.1016/j.ijppaw.2018.09.009.

2018 **Miller MA,** Raverty S, Shapiro K. Invited Author: Chapter 40-Marine Mammal Protozoa. *IN* CRC Handbook of Marine Mammal Medicine: Health, Disease, and Rehabilitation. Third Edition. L Dierauf, FM Gulland, & KI Whitman, Eds. CRC Press.

2018 Williams B, Burek-Huntington K, **Miller MA**. Diseases of Mustelids. Chapter 11. *IN* Pathology of Wildlife and Zoo Animals. Irst. Edit. K Terio, D McAloose and J St. Leger, Eds. Academic Press. Pp. 287-304.

2018 Burgess T, Tinker MT, **Miller MA**, Bodkin J, Murray M, Saarinen J, Conrad P, Johnson C. Defining the risk landscape in the context of pathogen pollution: *Toxoplasma gondii* in sea otters along the Pacific Rim. Royal Soc Open Sci. https://doi.org/10.1098/rsos.171178.

2018 Brown A, Foss A, **Miller MA**, Gibson QA. Detection of cyanotoxins (microcystins/nodularins) in livers from estuarine and coastal bottlenose dolphins (*Tursiops truncatus*) from Northeast Florida. Harmful Algae. DOI: 10.1016/j.hal.2018.04.011

2018 Gagne R, Tinker MT, Ralls K, Larson S, Tarjan LM, **Miller MA**, Ernest HB. Measures of effective population size in sea otters reveal special considerations for wide-ranging species. Evolutionary Applications. DOI: 10.1111/eva.12642

2017 Capuano AM, **Miller MA**, Stallknecht DE, Moriarty M, Plancarte M, Dodd E, Batac F, Boyce WM. Serologic Detection of Subtype-specific Antibodies to Influenza A Viruses in Southern Sea Otters (*Enhydra lutris nereis*). J Wildl Dis.53: 906-910. doi: 10.7589/2017-01-011.

2017 **Miller MA**, Burgess T, Dodd E, Ewalt D, Nielson K., Rhyan J, Jang S, Byrne B., Gulland F, Murray M, Smith W. <u>Erratum</u>: Isolation and characterization of a novel marine *Brucella* from a southern sea otter (*Enhydra lutris nereis*), California, USA. J Wildl Dis.

2017 Oates SC, **Miller MA**, Hardin D, Dominik C, Jessup D, Smith WA. Estimating daily relative dog abundance, fecal density and loading rates on two marine recreational beaches in Monterey County. Mar Pollut Bull. 125: 451-458. doi: 10.1016/j.marpolbul.2017.10.062.

2017 **Miller MA**, Moriarty ME, Dodd EM, Burgess T, Tinker MT, Batac FI, Henkel LA, Young C, Harris MD, Kreuder-Johnson C. 2017. The dead do tell tales: Investigating sea otter mortality patterns (1998-2012). Unpublished final report to California Coastal Conservancy, Oakland, CA. 156 pp.

2017 Young C, **Miller MA**, Newsome SD Dailey M. First report of intestinal cestodiasis in a southern sea otter. J Wildl. Dis. DOI: 10.7589/2017-01-020.

2017 **Miller MA**, Burgess T, Dodd E, Ewalt D, Nielson K, Rhyan J, Jang S, Byrne B, Gulland F, Murray M, Smith W. Isolation and characterization of a novel marine *Brucella* from a southern sea otter (*Enhydra lutris nereis*), California, USA. J Wildl. Dis. DOI: 10.7589/2015-12-326

2017 Shen Z, Batac F, Mannion A, **Miller MA**, Bakthavatchalu V, Ho C, Manning S, Paster BJ, Fox JG. Novel *Helicobacter* sp., '*H. enhydrae* sp. nov.' isolated from gastric tissue of Southern sea otters. Dis. Aquat. Organ. 123: 1-11. doi: 10.3354/dao03082.

2017 Siqueira J, Ng T, **Miller MA**, Li L, Deng X, Dodd E, Batac F, Delwart E. Endemic infection of stranded Southern sea otters (*Enhydra lutris nereis*) with novel parvovirus, polyomavirus and adenovirus. J Wildl. Dis. 53: 532-542. doi: 10.7589/2016-04-082.

2016 Lee B, Byrne BA, Young MA, Murray MA, **Miller MA**, Tell L. Pharmacokinetic parameters for adult southern sea otters (*Enhydra lutris nereis*) following a single subcutaneous dose of cefovecin sodium. J. Vet. Pharmacol. Therap. 39: 625-628.

2016 Ferguson SD, Wellehan JF, Frasca S, Innis CJ, Harris H, **Miller MA**, Weber E, Stockdale S, Walden H, Greiner EC, Merigo C, Stacy BS. Coccidial infection of the adrenal glands of leatherback sea turtles (*Dermochelys coriacea*). J Wildl. Dis. DOI 10.7589/2015-11-310.

2016 Lee EA, Byrne BA, Young MA, Murray M, **Miller MA**, Tell L. Pharmacokinetic parameters of cefovecin in adult sea otters *(Enhydra lutris).* J Vet. Pharmacol. Therap. doi: 10.1111/jvp.12322.

2016 Backer L, **Miller MA.** Applying a One Health Approach to Biotoxin Monitoring: Animals as Sentinels for Harmful Cyanobacteria and Algae Blooms. Vet. Sci. doi: 10.3390/vetsci3020008.

2016 Chinn S, **Miller MA**, Staedler M, Tinker M, Harris MD, Batac F, Dodd E, Henkel L. The high cost of motherhood: End-lactation syndrome (ELS) in southern sea otters (*Enhydra lutris nereis*). J Wildl. Dis. http://dx.doi.org/10.7589/2015-6-158. <u>Finalist: Linda Munson Award for best student wildlife disease manuscript for 2016 in the Journal of Wildlife Disease and Journal of Zoo and Wildlife Medicine</u>

2016 Bartlett B, Miller W, Dominik C, Batac F, Dodd E, Byrne B, Jang S, Jessup D, Chantrey J, **Miller MA.** Prevalence, pathology and potential risk factors associated with *Streptococcus phocae* infection in southern sea otters (*Enhydra lutris nereis*) (2004-2010). J Wildl. Dis. 52: 1-9. <u>Recipient: Linda Munson Award for best student wildlife disease manuscript for 2016 in the Journal of Wildlife Disease and Journal of Zoo and Wildlife Medicine</u>

2015 Shapiro K, **Miller MA**, Aguilar B, Packham A, Conrad P, VanWormer E, Murray M. Late-term abortion associated with congenital transmission of *Toxoplasma gondii* and *Sarcocystis neurona* in a chronically infected Southern sea otter (*Enhydra lutris nereis*). J Parasitol. DOI: 10.1017/S0031182015001377.

2015 Bentall GB, Rosen BH, Kunz JM, **Miller MA**, Saunders GW, LaRoche NL. Characterization of the putatively introduced red alga *Acrochaetium secundatum (Acrochaetiales, Rhodophyta)* growing epizoically on the pelage of southern sea otters (*Enhydra lutris nereis*). Mar. Mamm. Sci. DOI: 10.1111/mms.12275.

2015 Stacy B, Innis C, Daoust P, Wyneken J, **Miller MA**, Harris H, James M, Foley A. Solitary large intestinal diverticulitis in leatherback turtles (*Dermochelys coriacea*): a review of 27 cases. Vet. Path. 52: 712-715.

2015 Huckabone S, Gulland F, Johnson S, Colegrove K, Dodd E, Pappagianis D, Dunkin R, Casper D, Carlson E, Sykes JE, Meyer W, **Miller MA.** Coccidioidomycosis and other systemic mycoses of marine mammals stranding along the central California coast: 1998-2012. J Wildl. Dis. 51: 295-308. doi: 10.7589/2014-06-143.

2015 Fei Fan Ng T, **Miller MA**, Kondova NO, Dodd E, Manzer M, Ivesa S, Saliki JT, Deng X, Delwart E. Oral papillomatosis caused by *Enhydra lutris* papillomavirus 1 (ElPV-1) in Southern sea otters. J Wildl. Dis. 51: 446-453. doi: http://dx.doi.org/10.7589/2014-06-152

2014 Daniels ME, Hogan J, Smith WA, Oates SC, **Miller MA**, Hardin D, Shapiro K, Los Huertos M, Conrad PA, Dominik C, Watson F. Estimating environmental conditions affecting protozoal pathogen removal in surface water wetland systems using a multi-scale, model-based approach. Sci. Tot. Envir. 493: 1036-1046.

2014 Carrasco SE, Chomel BB, Gill VA, Kasten RW, Maggi RG, Breitschwerdt EB, Byrne BA, Burek KA, **Miller MA**, Goldstein T, Mazet JK. Novel *Bartonella* infection in northern and southern sea otters (*Enhydra lutris kenyoni* and *Enhydra lutris nereis*). Vet. Microbiol. 4; 170:325-34. doi: 10.1016/j.vetmic.2014.02.021.

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1990 **Chechowitz (Miller) MA.** Master's Thesis. Aspergillosis in common eiders (*Somateria mollissima*). University of New Hampshire.

1989 Pinkerton KE, Kendall JZ, Randall GC, **Chechowitz (Miller) MA**, Hyde DM, Plopper CG. Hypophysectomy and porcine fetal lung development. Am. J. Respir. Cell. Mol. Biol. 1989 1: 319-28.

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Curriculum Vitae

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EDUCATION:

- Master of Arts (MA) Ecology and Evolutionary Biology University of California, Santa Cruz, 2011
- Sampling and Experimental Design Moss Landing Marine Laboratories, 1997
- Bachelor of Arts (BA) Environmental Studies with Marine Science emphasis, University of California, Santa Cruz, 1986

WORK EXPERIENCE:

Monterey Bay Aquarium
Sea Otter Program Manager
May 2018 - Present
This position leads the sea otter team in Conservation Research by; (i) overseeing stranding response, animal care, surrogacy, and reintroduction operations; (ii) managing research and scientific content generation; (iii) coordinating internally with other related Aquarium departments; (iv) and maintaining collaborative relationships with external partners in governmental agencies, NGOs, other zoos and aquariums, and universities; and (vi)responsible for program budget

Monterey Bay Aquarium
Sea Otter Research Coordinator
August 1996 - April 2018
Duties include managing two to three staff, and training interns and up to 30 volunteers on collaborating research projects with our Sea Otter Alliance partners. Maintain various databases, analyze data and prepare manuscripts for publication. Additionally, prepare posters or spoken presentations for scientific, lay, and educational venues. Conduct research and oversee sea otter research projects that Monterey Bay Aquarium is participating in. Design and implement a research project for Monterey Bay Aquarium's "Project White Shark". Other duties include assisting students on research projects, and conducting media interviews when requested by the PR department.

Monterey Bay Aquarium
Senior Research Assistant
July 1993- July 1995
Field observations of wild and rehab sea otters, maintain various data bases, supervise volunteers, helped prepare manuscripts for publication, and help prepare posters and talks for conferences. In addition to above activities, also design research projects for the exhibit and rehab otters at the aquarium. Conduct interviews with media; work in conjunction with the Oiled Wildlife Care Network and the USFWS Sea Otter Stranding Network. Prepare and manage budget. Designated liaison for MBA with other institutions studying sea otters. Plan and organize workshops for volunteers.

Monterey Bay Aquarium
Part Time Gift and Bookstore Sales Person
July 1986 - July 1987
Tasks included working as a sales person in bookstore handling large sums of money and a variety of merchandise items along with interacting with visitors.

Monterey Bay Aquarium
Research Assistant
July 1986 - July 1993
Field observations of wild sea otters, maintained data bases, supervised volunteers, helped prepare manuscripts and posters for conferences.

Año Nuevo State Reserve, San Mateo CA
Park Interpretive Specialist
1984 - 1986
Worked in various aspects of State Parks, including Park Interpretive Specialist in which I was responsible for seeing that groups of people safely begin the second leg of their natural history tour. I provided natural history and biology interpretation of the State Park and resident elephant seals.

Año Nuevo State Reserve, San Mateo CA
State Park Intern and Natural History Interpreter
1983 - 1984
In charge of getting groups of 20 people organized and ready to begin the first stage of natural history walk. I was responsible for sales in the interpretive bookstore and operation of the store.

University of California, Santa Cruz, CA
Ocean Education Coordinator
1982 - 1983
My responsibilities included setting up and running the outreach program, hiring student interns, supervised their work, and coordinated school groups for tidepool tours at Natural Bridges State Park.

Details:

PROFESSIONAL MEMBERSHIPS

- Marine Mammal Society:
  Member since 1994

- Russian/American Sea Otter Working Group:
  Member since 1989

- Oiled Wildlife Care Network
  Member since 1989

PUBLICATIONS & PRESENTATIONS

Nicholson, T. E., Mayer, K. M., **Staedler, M. M.,** Fujii, J. A., Murray, M. J., Johnson, A. B., Tinker, M. T., Van Houtan, K. S., (2018). Gaps in kelp cover may threaten the recovery of California sea otters. *Ecography 41*; 1-12

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Miller, MA, Ames, J, Harris, M, Dodd, E, Jessup, D, Murray, M, **Staedler, M,** Gulland, F, Haulena, M, Hatfield, B, Gardner, IA, Lowenstine, LJ, Mazet, JK, Conrad, PA. "Sex, sharks and intrigue: true stories of sea otter mortality. National Wildlife Rehabilitator's Association Conference, Lake Tahoe, CA. March 2001.

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Riedman, M.L**., M.M. Staedler**, 1995. Foraging Strategies and Kleptopurcisitism in the California Sea Otter. Poster presented t the 11th Biennial Conference of the Biology of Marine Mammals. Dec. 1995.

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Seth D. Newsome

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Research Interests

Animal Ecology, Animal Eco-Physiology, Historical Ecology, Conservation Biology

Education

2000–2005 Ph.D., University of California Santa Cruz (Santa Cruz, CA)
Earth & Planetary Sciences Department

1995–1999 B.A., Dartmouth College (Hanover, NH)
Earth Sciences Department

Positions & Professional Development

2018– *Associate Professor*, Biology Department, University of New Mexico (Albuquerque, NM)

2014– *Associate Director,* University of New Mexico Center for Stable Isotopes

2013–2018 *Assistant Professor*, Biology Department, University of New Mexico (Albuquerque, NM)

2009–2012 *Post-Doctoral Research Scientist*, University of Wyoming (Laramie, WY)
Research focused on (1) using compound specific stable isotope analysis to quantify protein routing in mammals, birds and fish; (2) characterizing the ecology of an adaptive radiation in a group of South American songbirds via biochemical, physiological, and genetic tools. Advisors: Drs. Carlos Martinez del Rio and David G. Williams

2006–2009 *Post-Doctoral Research Scientist*, Carnegie Institution of Washington (Washington, DC)
Research focused on (1) development of stable isotope methods to assess ecological niche and eco-physiological variation, foraging specialization, and dispersal characteristics of mammals and birds; (2) human impacts on ecosystem change in Australia and southern California.
Advisor: Dr. Marilyn L. Fogel

2000–2005 *Ph.D. Candidate*, UC-Santa Cruz (Santa Cruz, CA)
Research focused on historic and prehistoric ecology of marine mammals, with emphasis on the northern fur seal in the northeast Pacific Ocean.
Advisor: Dr. Paul L. Koch

2000 *Senior Lab Technician*, Lawrence Berkeley National Laboratory (Berkeley, CA)
Managed stable isotope facility and conducted research using isotopic tracers to track fluid and contaminant migration through sediments and groundwater.
Advisor: Dr. Mark E. Conrad

1998–1999 *Senior Honors Thesis,* Dartmouth College (Hanover, NH)

Grants (2006–2019)

2019 National Science Foundation: Biological Oceanography ([redacted], pending)
“Heat, hydrodynamics, and heterotrophy: investigating the role of food supply in coral resilience to ocean warming”
Co-PI with Drs. Anne Cohen and Michael Fox (WHOI)

2019 National Science Foundation: Systematics and Biodiversity Science[redacted], pending)
“Small mammal microbiomes, arthropods, and helminths (SMASH)”
Co-PI with Drs. Joe Cook (UNM), Steve Greiman (GSU), and Derek Sikes (UAF)

2019 National Institutes of Justice: Biological Oceanography [redacted], pending)
“Compound-specific stable isotope analysis of human keratin tissues for migration and region of origin determination”
Co-PI with Dr. Christy Mancuso (UNM)

2018 FONDECyT–Chile ($[redacted]0)
“Using stable isotope values of prehistorical and contemporary marine consumers to characterize change and the role of natural and anthropogenic disturbance in coastal food webs over 13,000 years”
International Collaborator with PI Dr. Chris Harrod (University of Antofagasta)

2018 National Science Foundation: Advanced Biological Infrastructure [redacted])
“IsoBank: a centralized repository for isotopic data”
Lead PI with Co-PIs Drs. Jon Pauli (UWM), Chris Jordan (TACC), and Gabe Bowen (UU)

2018 National Science Foundation: Division of Integrative and Organismal Systems ([redacted])
“The role of gut microbiota in supplying amino acids to their mammalian hosts”
Lead PI with Co-PIs Drs. Cristina Takacs-Vesbach (UNM) and Marilyn Fogel (UCR)

2018 National Science Foundation: Division of Environmental Biology ($[redacted]0)
“LTER: Sevilleta (SEV) Site: Climate variability at dryland ecotones”
Co-PI with Drs. Jennifer Rudgers (UNM), Marcy Litvak (UNM), Yiqi Luo (OSU), and Tom Miller (Rice)

2017 National Science Foundation: Division of Environmental Biology [redacted]
“EAGER: Collaborative Research: Environmental variability at dryland ecotones”
Co-PI with Drs. Jennifer Rudgers (UNM), Marcy Litvak (UNM), Yiqi Luo (OSU), and Tom Miller (Rice)

2016 National Science Foundation: Biological Oceanography [redacted]
“The energetic assembly of biological communities: a test with deep-sea woodfalls”
Co-PI with Dr. Craig McClain (LUMCON)

2016 National Science Foundation: Division of Environmental Biology ([redacted]
“Moving beyond causation: the ecological consequences of the te[redacted]stocene extinction of North American megafauna.”
Co-PI with Drs. Felisa Smith (UNM) and Ka[redacted]ithsonian)

2016 National Science Foundation, Archaeology [redacted]
“Late Pleistocene and early Holocene clima[redacted]d human ecology in the tropical Maya lowlands”
Senior Personnel w[redacted]rs. Keith Prufer, Yemane Asmerom, Doug Kennett, Brendan Culleton

2016 FONDECyT–Chile [redacted]
“Passerine birds fa[redacted]environments: foraging on salty prey and fighting oxidative stress”
Senior Personnel with Co-PIs D[redacted]Sabat, Francisco Bozinovic, and Robert Nespolo

2015 North Pacific Research Board ([redacted]
“The effects of sea ice loss on [redacted]d fat stores of food-deprived polar bears”
Co-PI with Dr. Merav Ben-David (UW)

2014 National Science Foundation: Major Research Instrumentation ([redacted]
“MRI: acquisition of instrumentation for compound-specific stable isotope analysis at UNM”
Lead PI with Co-PIs Drs. Zach Sharp, Blair Wolf, Dave Hanson, and Tom Turner (UNM)

2014 United States Fish & Wildlife Service–King Salmon, AK ([redacted]
“Marine resource use and individual diet specialization of Alaska wolves”
Co-PI with Dom Watts (USFWS)

2013 Smithsonian Institution [redacted]
“Biodiversity, Genomics, and Human Ecology of California's Channel Islands”
Collaborator with Drs. Torben Rick, Scott Sillett, Rob Fleischer, Jesus Maldonado, Kathy Ralls

2013 United States Fish & Wildlife Service–King Salmon, AK [redacted]
“Marine resource use and individual diet specialization of Alaska Peninsula wolves”
Lead PI with Co-PI Dom Watts (USFWS)

2013 United States Geological Survey & National Park Service–Anchorage, AK ([redacted])
"Inter-tidal interactions among kelp and invertebrates in south central Alaska"
Lead PI

2012 North Pacific Research Boar[redacted])
"Retrospective study of walrus foraging and movement patterns during a major ecosystem shift in the Bering and Chukchi Seas"
Lead PI with Co-PIs Dr. Patrick R. Lemons (USFWS)

2012 National Park Service and U.S. Navy ($[redacted])
"Characterizing island fox dietary preferences across habitats on the Channel Islands"
Lead PI with Co-PI Drs. Katherine Ralls (Smithsonian) and Brian Cypher (CSUB)

2012 United States Geological Survey, Alaska Science Center–Anchorage, AK [redacted]
"Demographic parameters of walruses estimated from the analysis of stable isotopes in archived teeth"
Lead PI with Co-PI Dr. Dan Monson (USGS)

2012 United States Fish & Wildlife Service–Homer, AK ($[redacted]
"Determining sea otter forage taxa in southeast Alaska through isotope markers in vibrissae"
Lead PI with Co-PI Dr. Verena Gill (USFWS)

2012 United States Fish & Wildlife Service–King Salmon, AK ([redacted]
"Marine resource use and individual diet specialization of Alaska Peninsula wolves"
Lead PI with Co-PI Dom Watts (USFWS)

2011 FONDECyT–Chile ([redacted]
"The introduction of salmon in southern Chile and its effects on the trophic ecology of sea lions"
International Collaborator with PI Dr. Maritza Sepulveda Martinez (University of Valparaiso)

2011 United States Geological Survey, Alaska Science Center–Anchorage, AK ([redacted])
"Coastal ecosystem responses to influences from land and sea"
Co-Investigator with Co-PIs Drs. Jim Bodkin and Tim Tinker (USGS)

2011 National Science Foundation: Population and Community Ecology ([redacted])
"Extending the potential for hydrogen isotope tracers in ecology"
Lead PI with Co-PI Dr. Marilyn L. Fogel (Carnegie Institution of Washington)

2011 Montrose Settlements Restoration Program ([redacted]
"Quantifying the diets of breeding bald eagles on the Channel Islands: a multi-proxy approach"
Lead PI with Co-PIs Drs. Paul W. Collins (SBNHM) and Peter Sharpe (IWS)

2011 Australian Marine Mammal Centre ([redacted]
"Southern right whales and stable isotopes: toward defining feeding habitat and trophic ecology"
Co-PI with PIs Mark Hindell, Simon Childerhouse, and Glenn Dunshea

2011 United States Geological Survey, Alaska Science Center–Anchorage, AK ([redacted]0)
"Demographic parameters of walruses estimated from the analysis of stable isotopes in archived teeth"
Lead PI with Co-PI Dr. Dan Monson (USGS)

2011 Fisheries and Oceans Canada-Ottawa, CAN ($[redacted]
"Coupling isotopes and GPS-derived ringed seal movement data"
Lead PI with Co-PI Dr. Steve Ferguson (Fisheries & Oceans Canada)

2010 United States Fish & Wildlife Service–Homer, AK ($[redacted])
"Determining sea otter forage taxa in southeast Alaska through isotope markers in vibrissae"
Lead PI with Co-PI Dr. Verena Gill (USFWS)

2010 Montrose Settlements Restoration Program [redacted])
"Quantifying the diets of breeding bald eagles on the Channel Islands: a multi-proxy approach"
Lead PI with Co-PI Dr. Paul W. Collins (SBMNH)

2010 United States Geological Survey, Alaska Science Center–Anchorage, AK ([redacted])
"Coastal ecosystem responses to influences from land and sea
Lead PI with Co-PIs Drs. Jim Bodkin and Tim Tinker (USGS)

2008 National Science Foundation: Integrative Biology Program ([redacted]
"Isotopes, niches, and birds: the functional ecology of an adaptive radiation"
Senior Personnel with PI Dr. Carlos Martinez del Rio (UW)

2007 Smithsonian Walcott Fund [redacted]
"Stable isotope analysis of great gray owl (*Strix nebulosa*) invasions in North America"
Co-PI with Dr. Gary R. Graves (Smithsonian)

2007 Smithsonian Endowment Fund ($3[redacted]
"Evaluating dietary specialization in sea otters via fatty acid and stable isotope analysis"
Co-PI with Drs. Katherine Ralls & Olav Oftedal (Smithsonian)

2007 United States Fish & Wildlife Service-Anchorage, AK ([redacted]
"Investigating dietary links to valvular endocarditis in Lower Cook Inlet, AK sea otters"
Lead PI with Co-PIs Drs. Angela Doroff & Verena Gill (AKFWS)

2006 National Science Foundation: Biological Oceanography Program ([redacted])
"Holocene phylochronology and ecology of the northern fur seal"
Co-written with Drs. Liz Hadly & Marcel van Tuinen (Stanford University)

Peer-Reviewed Publications

*Student Author

Manuscripts in Review

Newsome, S.D., *Feeser, K., Bradley, C.J., *Wolf, C., Vesbach-Takacs, C., Fogel, M.L. (In Review) Quantifying the role of the gut microbiome in host essential amino acid metabolism. *ISME Journal*

Aurioles-Gamboa, D., Rosas Hernandez M., Hernandez Camacho, C., **Newsome, S.D.** (In Revision) Isotopic breadth and overlap in juvenile and adult female *Zalophus californianus*. *Marine Mammal Science.*

*Elliott Smith, E.A., Tinker, M.T., *Whistler, E.L., Kennett D.J., Vellanoweth, R.L., Gifford-Gonzalez, D., **Newsome, S.D.** (Submitted) The absent niche: range-wide historical ecology of the southern sea otter (*Enhydra lutris nereis*). *Conservation Biology.*

*Dyez, K.A., Koch, P.L., Ford, H.L., Schellenberg, S.A, **Newsome, S.D.**, Hylkema, M.G. (In Revision) Mollusk geochemical records show stable late Holocene climate on the central California coast. *The Holocene.*

*Fox, M.D., *Elliott Smith, E.A., Smith, J.E., **Newsome, S.D.** (In Revision) Amino acid $\delta^{13}C$ analysis reveals trophic plasticity in a common reef-building coral. *Functional Ecology.*

*Noble, J.D., Collins, S.L., *Hallmark, A.J., Wolf, B.O., **Newsome, S.D.** (In Review) Foraging strategies of individual silky pocket mice over a boom-bust population cycle in a highly stochastic arid ecosystem. *Oecologia.*

*Phillips, N.D., *Elliott Smith E.A., **Newsome, S.D.**, Houghton, J.D.R., Carson, C., Alfaro Shigueto, J., Mangel, J., Eagling, L.E., Harrod, C. (Submitted) Bulk tissue and amino acid stable isotope analysis reveal global ontogenetic patterns in ocean sunfish diet and habitat use. *Marine Ecology Progress Series.*

*Polo-Silva, C., Newsome, S.D., Kim, S.L., Soto-Jimenez, M.F., O'Hara, T.M., Galvan-Magana, F. (In Review) Ontogenetic variation in diet and habitat use of blue sharks (*Prionace glauca*) in the Mexican Pacific determined from stable isotope analysis. *Marine Ecology Progress Series*.

*Tome, C.P., *Elliott Smith, E.A., Lyons, S.K., Stafford, T.W., **Newsome, S.D.,** Smith, F.A. (In Review) The response of a small herbivorous mammal (*Sigmodon hispidus*, hispid cotton rat) to the late Pleistocene megafauna extinction. *Ecography.*

2019

Aurioles-Gamboa, D., **Newsome, S.D.**, Hassrick, J., Acosta-Pachon, T., Aurioles-Rodriguez, F., Costa, D.P. (2019) Vibrissa growth rates in free ranging northern elephant seal females (*Mirounga angustirostris*). *Marine Ecology Progress Series* 614: 199–207.

*Carter, W., Whiteman, J.P., Cooper-Mullin C., **Newsome, S.D.**, McWilliams, S. (2019) The dynamics of zebra finch flight muscle lipids revealed by fatty acid turnover. *Physiological and Biochemical Zoology.* 92: 239–251.

Maldonado, K., **Newsome, S.D.**, Razeto-Barry, P., Manuel Rios, J., Piriz, G., Sabat, P. (2019) Individual diet specialization is driven by phenotypic plasticity in digestive enzymes and trade-offs in animal performance. *Ecology Letters* 22: 128–137.

Sabat, P., Bozinovic, F., Contreras-Ramos, C., Nespolo, R., **Newsome, S.D.**, Quirici, V., Maldonado, K., Ramirez-Otarola, N., Sanchez-Hernandez, J.C. (In Press) The interplay between ambient temperature and salt intake affects oxidative status and immune responses in a ubiquitous Neotropical passerine, the rufous-collared sparrow. *Comparative Biochemistry and Physiology A.*

Tinker, M.T., Tomoleoni, J.A., Wietzman, B.P., Staedler, M., Jessup, D., Murray, M.J., Miller, M., Burgess, T., Bowen, L., Miles, A.K., Thometz, N., Tarjan, L., Golson, E., Batac, F., Dodd, E., Berberich, E., Kunz, J., Bentall, G., Fujii, J., Nicholson, T., **Newsome, S.D.**, Melli, A., LaRoche N., MacCormick H, Johnson, A., Henkel, L., Kreuder-Johnson, C., Conrad, P. (2019) Southern sea otter (Enhydra lutris nereis) population biology at Big Sur and Monterey, California — Investigating the consequences of resource abundance and anthropogenic stressors for sea otter recovery. *USGS Open-File Report 2019-1022*.

*Vokhshoori, N., McCarthy, M.D., Collins, P.W., Etnier, M.A., Rick, T.C., **Newsome, S.D.** (2019) Evaluating long-term shifts in the distribution and diet of North Pacific albatrosses with bulk tissue and amino acid isotope values. *Marine Ecology Progress Series* 610: 1–13.

Whiteman, J.P., *Elliott Smith E.A., *Besser, A.C., **Newsome, S.D.** (2019) A guide to using compound-specific stable isotope analysis to study molecules, organisms, and ecosystems. *Diversity* 11: 8.

Whiteman, J.P., Sharp, Z.D., Gerson, A.R., **Newsome, S.D.** (In Press) Relating $\Delta^{17}O$ values of animal body water to exogenous water inputs and metabolism. *BioScience.*

2018

Newsome, S.D., Chivers, S., Berman Kowalewski, M. (2018) The influence of lipid-extraction and long-term dimethyl sulfoxide preservation on carbon and nitrogen isotope values in cetacean skin. *Marine Mammal Science* 34:277–293.

*Elliott Smith, E.A., Harrod, C., **Newsome, S.D.** (2018) Untangling the importance of kelp carbon to an intertidal ecosystem using amino acid $\delta^{13}C$ analysis. *Ecosphere* 9: e02516.

*Gadek, C.R., **Newsome, S.D.**, Beckman, E.J., Chavez, E.N., Galen, S.C., Witt, C.C. (2018) Why are tropical mountain passes low for some species? Genetic and stable isotope tests for differentiation, migration, and expansion in elevational generalist songbirds. *Journal of Animal Ecology* 87:741–753.

Graves, G.R., **Newsome, S.D.**, Fogel, M.L. (2018) Stable hydrogen isotope variability in feather keratin of a migratory wood warbler. *PLoSONE* 13: e0193486.

*Hixon, S.W., *Elliott Smith E.A., Crowley B., Perry, G., Bankoff, R., Kennett, D., **Newsome, S.D.** (2018) Patterns in $\delta^{15}N$ values for amino acids in lemur bone are inconsistent with aridity driving megafaunal extinction in southwestern Madagascar. *Journal of Quaternary Science* 33: 958–968.

Hobson, K.A., Wassenaar, L.I., Bowen, G.J., Courtiol, A., Trueman, C.V., Voight, C.C., West, J.B., McMahon, K.W., **Newsome, S.D.** (2018) Outlook for using stable isotopes in animal migration studies. *Tracking Animal Migration with Stable Isotopes.* K.A. Hobson, L.I. Wassenaar, editors. Elsevier.

*Hughes, K., Whiteman, J.P., **Newsome, S.D.** (2018) The relationship between dietary protein content, body condition, and $\delta^{15}N$ discrimination in a mammalian omnivore. *Oecologia* 186: 357–367.

McMahon, K.W., **Newsome, S.D.** (2018) Compound-specific isotope analysis: the next frontier in isotopic tracking of animals. *Tracking Animal Movement with Stable Isotopes*. K.A. Hobson, L.I. Wassenaar, editors, Elsevier.

*Poblete, Y., Gutierrez, V., Venegas, C., Cid, V., **Newsome, S.D.**, Sabat, P., Vasquez, R. (2018) Behavioral and morphometric differences among populations: exploration and migration at different altitudes in Rufous collared sparrow. *Oecologia* 186: 931–938.

Resasco, J., Tuff, K., Cunningham, S.A., Melbourne, B.A., Hicks, A., **Newsome, S.D.**, Davies, K.F. (2018) Experimental forest fragmentation alters food-web structure and the environment: evidence from a generalist predator's niche shift. *Ecography* 41: 1209–1219.

*Rodriguez Curras, M.R., Fogel, M.L., **Newsome, S.D.** (2018) Assimilation and discrimination of hydrogen isotopes in a terrestrial mammal. *Oecologia* 188: 381–393.

*Rodriguez Perez, M.Y., Aurioles-Gamboa, D., Sanchez-Velasco, L., Lavin, M.F., **Newsome, S.D.** (2018) Isoscape of the upper Gulf of California: a tool for identifying critical habitat for the endemic and endangered vaquita (*Phocoena sinus*). *Marine Mammal Science* 34: 790–805.

*Tapia-Monsalve, R., **Newsome, S.D.**, Sanchez-Hernandez J.C., Bozinovic, F. Nespolo, R., Sabat P. (2018) Terrestrial birds in coastal environments: metabolic rate and oxidative status varies with the use of marine resources. *Oecologia* 188: 65–73.

Whiteman, J.P., Kim, S.L., McMahon, K.W., Koch, P.L., **Newsome, S.D.** (2018). Amino acid isotope discrimination factors for a carnivore: physiological insights from leopard sharks and their diet. *Oecologia* 188: 977–989.

2017

Newsome, S.D., Wolf, N., Bradley, C.J., Fogel, M.L. (2017) Hydrogen isotope assimilation and discrimination in tilapia: implications for studying animal diet with δ^2H. *Ecosphere* 8.

Braje, T.J., Rick, T.C., Szpak, P., **Newsome, S.D.**, McCain, J.M., *Elliott Smith, E.A., Glassow, M., Thakar, H. (2017) Historical ecology and the conservation of large, hermaphroditic fishes in Pacific coast kelp forest ecosystems. *Science Advances* 3: e1601759.

*Busquets-Vass G., **Newsome, S.D.**, Calambokidis, J., Aguiniga-Garcia, S., Serra-Valente, G., Jacobsen, J., Gendron, D. (2017) Estimating blue whale skin isotopic incorporation rates and baleen growth rates: implications for assessing diet and movement pattern in mysticetes *PLoSOne* 12: e0177880.

Maldonado, K., Bozinoviz, F., **Newsome, S.D.**, Sabat, P. (2017) Testing the niche variation hypothesis in a community of passerine birds. *Ecology* 98: 903–908.

*O'Brien, S.L., Cook, J.A., **Newsome, S.D.** (2017) Small mammal niche differentiation within the Alexander Archipelago, Southeast Alaska. *Journal of Mammalogy* 99: 108–116.

Pauli, J.N., **Newsome, S.D.**, Cook, J.A., Harrod, C., Steffan, S.A., Baker, C.J.O., Ben-David, M., Bloom, D., Bowen, G.J., Cerling, T., Cicero, C., Cook, C., Dohm, M., Dharampal, P.S., Graves, G.R., Gropp, R., Hobson, K.A., Jordan, C., MacFadden, B.J., Pilaar Birch, S., Poelen, J., Ratnasingham, S., Russell, L., Stricker, C.A., Uhen, M.D., Yarnes, C.T., Hayden, B. (2017) Opinion: Why we need a centralized repository for isotopic data. *Proceedings of the National Academy of Sciences USA* 114: 2997–3001.

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*Busquets-Vass, G., **Newsome, S.D.**, Pardo, M., Calambokidis, J., Serra-Valente, G., Jacobsen, J.K., Aguiniga-Garcia, S., Paez-Rosas, D., Gomez-Gutierrez, J., Gendron, D. Isotopic niche and diet of blue whales in the eastern Pacific Ocean. *Marine Ecology Progress Series.*

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Whiteman, J.P., Hobson, K.A., Cherel, Y., **Newsome, S.D.** Nutrient allocation differs between egg yolk and albumen in a capital breeder. *Physiological and Biochemical Zoology.*

*Wurth, A.M., **Newsome, S.D.**, Gehrt, S.D. Influence of urbanization on body size and condition of coyotes (*Canis latrans*) in the Chicago Metropolitan area. *Oecologia.*

Teaching & Advising Experience

Assistant/Associate Professor, University of New Mexico Department of Biology

Evolution & Ecology (Biology 303): Fall 2013, Spring 2015, Spring 2017, Spring 2018
Elemental Ecology (Biology 409/509): Spring 2014, Fall 2015, Fall 2017, Fall 2019
Biodiversity (Biology 191): Fall 2018
Ecology of the Past (Biology 409/509): Fall 2014, Fall 2016
Senior Honors Thesis Writing Seminar; Spring 2015–2018
Center for Stable Isotopes Brown Bag Seminar; 2014–2019 (every semester)
Applied Wildlife Ecology; Fall 2016

UNM Biology Department Committee Participation

Annual Review Committee: 2017–2018
Development of Ecology Concentration: 2013
Biology Scholarship Committee: 2013–2014
Undergraduate Honors Thesis Committee: 2013–2017

Organizer and Lecturer, Isotope Ecology Short Courses

Design and co-teach one- or two-week intensive short courses for graduate students and postdoctoral scientists on the uses of stable isotope analysis to study the ecology and physiology of marine and terrestrial plants and animals.

June 2013–2019: University of Utah (Salt Lake City, UT)
April 2017–2018: Sicily Center for International Education (Siracusa, Italy)
March 2012, July 2017, July 2019: Instituto Politecnico Nacional (La Paz, Mexico)
July 2017: Universidad de Guanajuato (Leon, Mexico)
March 2009: Universidad de La Plata (La Plata, Argentina)
May 2013: Centro Austral De Interdiciplinario Cientificas (Ushuaia, Argentina)
January 2012: Universidad de Los Lagos (Puerto Montt, Chile)
November 2012: Universidad de Chile (Santiago, Chile)

***Graduate Student Thesis Committee Member* (*Primary Advisor, †Graduated)**

*Emma Elliott Smith (PhD) – UNM Biology Department (Albuquerque, NM)
*†Deborah Boro (MS) – UNM Biology Department (Albuquerque, NM)
*†Laura Pages (MS) – UNM Biology Department (Albuquerque, NM)
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†Meghan Balk (PhD) – UNM Biology Department (Albuquerque, NM)
†Matt Baumann (MS) – UNM Biology Department (Albuquerque, NM)
†Corrie Bergman (MS) – UNM Biology Department (Albuquerque, NM)
†Jennifer Noble (PhD) – UNM Biology Department (Albuquerque, NM)
†Melissa Pardi (PhD) – UNM Biology Department (Albuquerque, NM)
Catalina Tome (PhD) – UNM Biology Department (Albuquerque, NM)
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†Cyler Conrad (PhD) – UNM Anthropology Department (Albuquerque, NM)
†Marian Hamilton – UNM Anthropology Department (Albuquerque, NM)
Clayton Meredith – UNM Anthropology Department (Albuquerque, NM)
Jon Dombrosky – UNM Anthropology Department (Albuquerque, NM)
†Carl Cloyed – University of Louisville (Louisville, KY)
†Carlos Polo – Universidad Nacional Autonoma de Mexico (Mexico City, Mexico)
†Geraldine Busquets – Instituto Politecnico Nacional (La Paz, Mexico)
Carlos Alberto – Instituto Politecnico Nacional (La Paz, Mexico)
Yamila Becker – Centro Austral De Interdiciplinario Cientificas (Ushuaia, Argentina)

B.S. Senior Honors Thesis Students

Sarah Foster; Spring 2015; B.S. Biology; *Magna Cum Laude.*
Allyson Richins; Spring 2015; B.S. Biology; *Summa Cum Laude*
Mauriel Curras Rodriguez; Spring 2016; B.S. Biology; *Summa Cum Laude*
Chauncey Gadek; Spring 2016; B.S. Biology; *Summa Cum Laude*
Shannon O'Brien; 2017; B.S. Psychology (Honors College); *Summa Cum Laude*

Tommy Galfano; 2019 (Expected); B.S. Biology
Vishwa Patel; 2020 (Expected); B.S. Environmental Sciences
Alana Robinson; 2021 (Expected); B.S. Biology

***Teaching Assistant* (UC-Santa Cruz, 2000–2005)**

Served as teaching assistant and lab coordinator for five undergraduate courses in the Earth Sciences Department, including *The Natural History of Dinosaurs (2x), Vertebrate Paleontology, The Fossil Record,* and *The Earth as a Chemical System*.

***Field Course Teaching Assistant* (Dartmouth College, 1997–1999)**

Served as teaching assistant and logistical coordinator for six field-based undergraduate courses focusing on stratigraphy, paleontology, tectonics, structural geology, mineralogy, hydrology, and geochemistry. These intensive 3-week field programs were staged in the Bighorn Basin of Wyoming (1997/98/99), Yellowstone National Park (1997/98), and Costa Rica (1999).

Shawn P. Johnson, D.V.M., M.P.V.M.

Licensed in: CA 12619, AK 511 DEA Registration: BJ8945555

[redacted]
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johnsons@tmmc.org

EDUCATION

Don Low Practitioner Fellowship in Anesthesia, 2012
University of California - Davis, School of Veterinary Medicine

Master of Preventive Veterinary Medicine, December 2002
University of California - Davis, School of Veterinary Medicine
Advisors: Linda Lowenstein, Ian Gardner
Thesis: Aerobic bacterial flora of the vagina and prepuce in California sea lions and investigation of associations with urogenital carcinomas

Doctor of Veterinary Medicine, 1996
Iowa State University, College of Veterinary Medicine

AquaVet I & II, 1993, 1996
Marine Biological Laboratory, Woods Hole, MA.

Exchange Abroad Program
Flinders University, Adelaide, South Australia, 1992

Incomplete B. A., Aquatic Biology, Pre-Vet emphasis, 1989-92
University of California, Santa Barbara

PROFESSIONAL EXPERIENCE

The Marine Mammal Center
Director of Veterinary Science, 2010 – present
Supervisor: Jeff Boehm

- Manage all aspects of animal care and research for an average of 600 stranded marine mammals yearly.
- Supervise 17 staff in the veterinary, stranding, and research departments
- Member IACUC for TMMC research
- Hawaiian monk seal rehabilitation at hospital in Kona, Hawaii.

U. S. Navy Marine Mammal Program, National Marine Mammal Foundation
Clinical Veterinarian, June 2006 – 2010
Supervisors: Eric Jenson (Navy), Cynthia Smith (Foundation)

- Sea lion and dolphin preventive medicine program, clinical care, and surgery
  -Attending veterinarian for a population of over 25 sea lions and 75 dolphins
  -Deployment worldwide to provide veterinary support for Navy animals
- Research:
  -Managed study of renal disease in bottlenose dolphins
  -Performed renal scintrigraphy and CT exams to evaluate renal function
  -Managed stem cell and regenerative medicine study in bottlenose dolphins
  -Developed adipose stem cell collection technique
- Development of Techniques:

-Phlebotomy therapy for iron overload in bottlenose dolphins
-Advanced endodontic techniques for sea lion dental disease
-Transhepatic catheterization in bottlenose dolphins
-Arterial catheterization for anesthesia monitoring in sea lions

Marine Mammal Veterinary Consultant

National Marine Mammal Laboratory, Alaska Science Center, August 2004 – present
Supervisor: Peter Boveng,

- Polar Ecosystem Program contract veterinarian/capture team member
- MMPA permitted research projects
- Provided veterinary support and training while living on boat and field camps in close quarters with scientists and crew.
  -Harbor seal captures and sedation in Cook Inlet, AK
  -Bearded seal capture and sedation in Kotzebue Sound, AK

Alaska SeaLife Center, 2005 – present
Supervisor: Jo-Anne Mellish

- Veterinary anesthesia and surgical support for juvenile Steller sea lion Life History Transmitter project performed un MMPA permits and IACUC approval. Worked on ship for up to 14 days in Prince Williams Sounds with research team.

Alaska Department of Fish and Game, November 2003 – 2009
Supervisors: Tom Galett, Lorrie Rea

- Captured and anesthetized over 100 sea lions for biological sampling and research
  -Steller sea lions: juvenile captures and pup branding in AK and Russia
  -Harbor seals: anesthesia and surgical transmitter implants in Glacier Bay, AK

The Marine Mammal Center, Hawaiian Monk Seal Second Chance Program, January 2004
Supervisors: Frances Gulland, Bob Braun

- Seal rehab team leader on Tern Island, French Frigate Shoals

Wildlife Health Center, School of Veterinary Medicine, University of California - Davis
Wildlife Veterinarian, March 2005 – January 2006
Supervisor: Michael Ziccardi

- NOAA/National Marine Fisheries Service Contract:
  -Development of National Guidelines for response to oiled marine mammals
  -Taught two-day oil spill response trainings to NOAA regional marine mammal stranding networks

Alaska SeaLife Center, December 2003 - December 2004
Associate Veterinarian and Rehabilitation Manager
Supervisor: Pam Tuomi

- Responsible for captive care and research assistance for marine mammals, fish, and birds
- Managed rehabilitation department, staff, interns, and local stranding network volunteers
- Steller sea lions: veterinary support and anesthesia for Transient Juvenile Sea Lion Project
- Grant funded research project: Evaluation of Hemoglobinometer in Aquatic Birds

Oiled Wildlife Care Network, Wildlife Health Center, University of California-Davis
Oil Spill Response Veterinarian, December 2002 - August 2003
Supervisor: Michael Ziccardi

- Clinical Veterinarian at San Francisco Bay Area Oil Spill Care Clinic
  -Managed clinical care for seabirds in rehabilitation and related research projects
  -Trained rehabilitation staff and volunteers in avian medicine and oil spill response
- Provided clinical veterinary services and emergency care to seabirds and marine mammals

exposed to petroleum products in California

- Revised and update current protocols for the care of oiled marine mammals and seabirds
- Assisted teaching volunteers, rehabilitators, and students during oil spill response trainings
- Research and projects:
  - Treatment of anemia in oiled seabirds
  - Use of hemoglobin to diagnose anemia in avian species

The Marine Mammal Center

Adjunct Veterinarian, 2000 - 2002
Supervisor: Frances Gulland

- Performed clinical duties and necropsies on as needed basis
- Mentored and trained veterinary students
- Research projects:
  - Amoxicillin pharmacokinetics in harbor seals and northern elephant seals
  - Antimicrobial susceptibility of bacteria isolated from stranded pinnipeds
  - *Arcanobacterium phocae*: prevalence and clinical manifestations
  - Vaginal and preputial bacterial flora of California sea lions

International Bird Rescue

Oil Spill Response and Rehabilitation Veterinarian, October 1999 - February 2000
Supervisor: Jay Holcomb

- Provided medical care for oiled wildlife during oil spill response
- Lead veterinary care techniques for seabirds and marine mammals in oil spill response trainings
- Developed clinical research in an effort to improve survival of oiled wildlife

Johnson Veterinary Service: Veterinary Relief and Emergency

Part-time and independent contractor in Alaska and California, April 1997 - Present

- Small and exotic animal medicine and surgery
- Some of my veterinary employers:
  - Fairfax Veterinary Clinic, Dave Mohler, DVM
  - Mill Valley Pet Clinic, Charles Comella, VMD
  - Ross Valley Veterinary Clinic, Grace Bransford, DVM
  - Acorn Veterinary Clinic, Sally Borges, DVM
  - Sacramento SPCA, Giselle Chan, DVM

VetSmart Pet Hospitals and Health Centers

Practice Partner and Hospital Director, June 1996 - April 1997

- Small animal medicine and surgery
- Practice management and development: inventory, employee, client, marketing

PROFESSIONAL AFFILIATIONS

American Veterinary Medical Association
International Association for Aquatic Animal Medicine
American Association of Zoo Veterinarians
Society of Marine Mammalogy
Omega Tau Sigma, Professional Veterinary Fraternity

PUBLICATIONS

Fahlman A, Loring SH, **Johnson SP**, Haulena M, Trites AW, Fravel VA and 770 Van Bonn WG (2014) Inflation and deflation pressure-volume loops in anesthetized 771 pinnipeds confirms compliant chest and lungs. Front. Physiol. **5**:433. doi: 10.3389/ 772 fphys.2014.00433

Sterling JT, Springer AM, Iverson SJ, **Johnson SP**, Pelland NA, Johnson DS, Lea M, Bond NA (2014) The Sun, Moon, Wind, and Biological Imperative-Shaping Contrasting Wintertime Migration and Foraging Strategies of Adult Male and Female Northern Fur Seals (Callorhinus ursinus). PloS ONE 9:e93068

Cassle SE, Jensen ED, Smith CR, Meegan JM, **Johnson SP**, Lutmerding B, Ridgway S, Francis-Floyd R (2013) Diagnosis and successful treatment of a lung abscess associated with Brucella species infection in a bottlenose dolphin (*tursiops truncatus*). Journal of Zoo and Wildlife Medicine 44:495-99.

Smith CR, Venn-Watson S, Wells RS, **Johnson SP**, Maffeo N, Balmer BC, Jensen ED, Townsend FI and Sakhaee K (2013) Comparison of nephrolithiasis prevalence in two bottlenose dolphin (*Tursiops truncatus*) populations. Frontiers in Endocrinology 4:145.

Smith CR, Solano M, Lutmerding BA, **Johnson SP**, Meegan JM, Le-Bert CR, Emory-Gomez F, Cassle S, Carlin K, Jensen ED (2012) Pulmonary ultrasound findings in a bottlenose dolphin *Tursiops truncatus* population. Diseases of Aquatic Organisms 101: 243-55.

Johnson SP, Catania JM, Harman RJ, Jensen ED (2012) Adipose-derived stem cell collection and characterization in bottlenose dolphins (*Tursiops truncatus*). Stem Cells and Development 21: 2949-2957.

Mazzaro LM, Johnson SP, Fair PA, Bossart G, Carlin KP, Jensen ED, Smith CR, Andrews GA, Chavey PS, Venn-Watson S (2012) Iron indices in bottlenose dolphins (*Tursiops truncates*). Comparative Medicine 62:508-15.

Houser DS, Moore PW, **Johnson S**, Lutmerding B, Branstetter B, Ridgway SH, Trickey J, Finneran JJ, Jensen, Hoh C (2010) Relationship of blood flow and metabolism to acoustic processing centers of the dolphin brain. Journal of the Acoustical Society of America 128: 1460-1466.

Venn-Watson S, Smith CR, **Johnson SP**, Daniels R, Townsend F (2010) Clinical relevance of urate nephrolithiasis in bottlenose dolphins (*Tursiops truncatus*) Diseases of Aquatic Organisms 89:167-177.

Johnson SP, Venn-Watson S, Cassle SE, Smith CR, Jensen ED, Ridgway SH (2009) Use of phlebotomy treatment in bottlenose dolphins with iron overload. Journal of the American Veterinary Medical Association 235:194-200.

Johnson S, Ziccardi M (2006) Marine Mammal Oil Spill Response Guidelines. NOAA Technical Memorandum

Johnson SP, Lowenstine L, Gulland FMD, Jang S, Imai D, Almy F, Delong R, Gardner I (2006) Aerobic bacterial flora of the vagina and prepuce in California sea lions (*Zalophus californianus*) and investigation of associations with urogenital carcinomas. Veterinary Microbiology 114: 94-103.

Johnson SP, Jang S, Gulland FMD, Miller MA, Casper DR, Lawrence J, Herrera J (2002) Characterization and clinical manifestations of *Arcanobacterium phocae* infections in Marine mammals stranded along the central California coast. Journal of Wildlife Diseases. 38(1): 136-144.

Gulland FM, Stoskopf MK, **Johnson SP**, Riviere J, Papich MG (2000) Amoxicillin pharmacokinetics in harbor seals (Phoca vitulina) and northern elephant seals (*Mirounga angustirostris*) following single dose intravenous administration: Implications for interspecific dose scaling. Journal of Veterinary Pharmacology and Therapeutics 23 (4): 223-228.

Goldstein T, **Johnson SP**, Phillips AV, Hanni KD, Fauquier DA, Gulland FM (1999) Human-related injuries observed in live stranded pinnipeds along the central California coast 1986-1998. Aquatic Mammals. 25(1): 43-51.

Johnson SP, Nolan S, Gulland FM (1998) Antimicrobial susceptibility of bacteria isolated from pinnipeds stranded in central and northern California. Journal of Zoo and Wildlife Medicine. 29(3): 288-294.

Goldstein T, **Johnson SP**, Werner LJ, Nolan S, Hilliard BA (1998) Causes of erroneous white blood cell counts and differentials in clinically healthy young Northern elephant seals (*Mirounga angustirostris*). Journal of Zoo and Wildlife Medicine. 29(4): 408-412.

CLAIRE SIMEONE

[redacted]
simeonec@tmmc.org

CURRENT POSITION

NOAA-NMFS/The Marine Mammal Center — **Sausalito, CA**
Conservation Medicine Officer — **2013-Present**

Main projects include Unusual Mortality Event response, international capacity-building, field work veterinary support, and development of the Marine Mammal Health Map. Program Coordinator of International Veterinary In-Residence training program at TMMC.

EDUCATION

National Marine Mammal Foundation/SeaWorld San Diego — **San Diego, CA**
Specialty Intern — **2012-2013**

Veterinary Specialty Hospital — **San Diego, CA**
Small Animal Rotating Intern — **2011-2012**

Virginia-Maryland Regional College of Veterinary Medicine — **Blacksburg, VA**
Doctor of Veterinary Medicine — **May, 2011**

University of Maryland — **College Park, MD**
B.Sc. - Physiology and Neurobiology — **May, 2007**

LICENSES/CERTIFICATES

California Veterinary Medical Board — **Sacramento, CA**
License Number: 18691 — **June, 2011**

USDA-APHIS Category II Veterinary Accreditation — **Sacramento, CA**
National Accreditation Number: 059027 — **June 2011**

Oiled Wildlife Care Network – Oil Spill Response — **Sausalito, CA**
24 Hour HAZWOPER — **April, 2014**

CLINICAL EXPERIENCE

2013 – present **TMMC – Sausalito, CA and Kona, HI**
Clinical veterinary care of pinnipeds. Responsibilities include primary care of California sea lions, northern elephant seals, harbor seals, fur seals, and endangered Hawaiian monk seals; necropsy of pinnipeds and cetaceans.

2013 – present **TMMC – International Veterinary In-Residence training program**
Program coordinator. Participants spend three months training at TMMC main hospital in Sausalito, CA in marine mammal medicine, anesthesia, surgery, necropsy, and rescue/release. Responsibilities included participant selection, mentorship in clinical responsibilities and development of research project.

2014, 2015 **NOAA/TMMC/NMML – Aleutian Islands, AK**
Harbor seal population monitoring. Responsibilities included injectable sedation and anesthetic monitoring of phocids, biopsy, sample collection.

2014 **TMMC/NMML – San Miguel Island, CA**
California sea lion and northern fur seal population health assessment. Responsibilities included inhalant anesthesia and monitoring of otariids, sample collection.

2014 **NOAA/TMMC – Barataria Bay, LA**
Natural Resource Damage Assessments – dolphin health assessments. Responsibilities included monitoring, biopsy, sample collection.

2013 **NOAA/TMMC – Virginia Beach, VA; Myrtle Beach, SC**
Cetacean field response and necropsy.

2013-2014 **NOAA/TMMC – Molokai; Kauai, HI**
Endangered Hawaiian monk seal CritterCam placement. Responsibilities included injectable sedation, monitoring, venipuncture, and sample collection.

2013 **NOAA/NMML – Aleutian Islands, AK**
Pup anesthesia for branding and sample collection work at multiple sites along Aleutian Island chain. Responsibilities included inhalant anesthesia, monitoring, and sample collection.

2013-2014 **NOAA/Monterey Bay Aquarium – Gaviota, CA**
Sea otter transmitter placement and retrieval. Responsibilities included injectable immobilization, laparatomy, monitoring, venipuncture, and sample collection.

2012-2013 **National Marine Mammal Foundation – San Diego, CA**
Clinical internship – marine mammal medicine. Veterinary care of captive California sea lions and bottlenose dolphins. Advanced diagnostics including endoscopy, ultrasound, anesthesia, MRI.

2012-2013 **SeaWorld – San Diego, CA**
Clinical internship – marine animal medicine. Veterinary care of captive mammal, avian, reptile, and fish species. Rehabilitation of marine mammal and avian species.

MANUSCRIPTS

Johnson SP, **Simeone CA**. Disease. In: Castellini M, Mellish J (eds.). *Marine Mammal Physiology: Requisites for Ocean Living*. CRC Press. *In final review for publication.*

Simeone C, Gulland F, Norris T, Rowles T. 2015. A systematic review of changes in marine mammal health in North American since passage of the Marine Mammal Protection Act of 1972. In final review at *PLoS One*.

Gutierrez J, **Simeone C**, Gulland F, Johnson S. 2014. Development of a retrobulbar and auriculopalpebral nerve block in California sea lions (*Zalophus californianus*). Accepted for publication in *Journal of Zoo and Wildlife Medicine*.

Nuckton T, **Simeone C**, Jones R. 2014. California sea lion (*Zalophus californianus*) and harbor seal (*Phoca vitulina*) bites and contact abrasions in open-water swimmers: A series of 11 cases. Accepted for publication in *Wilderness and Environmental Medicine*.

Esson DW, Nollens HH, Schmitt TR, **Simeone CA**, Stewart B. 2015. Aphakic phacoemulsification and automated anterior vitrectomy and post-return monitoring of a rehabilitated harbor seal (Phoca vitulina richardsi) pup. *Journal of Zoo and Wildlife Medicine* 46(3):647-651.

Phan TG, Gulland F, **Simeone C**, Deng X, Delwart E. 2014. Sesavirus: prototype of a new parvovirus genus in feces of a sea lion. *Virus Genes* Epub Oct 2, 2014.

Simeone CA, Papich M, Nollens H, Meegan JM, Schmitt T, Jensen ED, Smith, CR. 2014. Pharmacokinetics of single-dose oral meloxicam in bottlenose dolphins (*Tursiops truncatus*). *Journal of Zoo and Wildlife Medicine* 45(3): 594-599.

Simeone CA, St. Leger J, Nollens H, Schmitt T. Characterization of a follicular cell carcinoma of the thyroid in a yellowbar angelfish (*Pomacanthus maculosus*). *Journal of Zoo and Wildlife Medicine* 46(2): 431-434.

Gomez M, Mieres M, Moroni M, Mora A, Barrios N, **Simeone C**, Lindsay D. 2010. Meningomyelitis due to nematode infection (*Gurltia paralysans*) in four cats. *Veterinary Parasitology* 170: 327-330.

SELECTED PRESENTATIONS

Simeone C. I am Dr. Claire Simeone of The Marine Mammal Center and I am working on the sea lion crisis our coast is facing. Invited participant, Reddit Ask Me Anything for World Ocean's Day.
Simeone C. Conserving San Francisco Bay: What Marine Mammal Health Can Teach Us About the Health of the Bay. Bay Science Collaborative, Romberg Tiburon Science Center, 2015. Oral presentation.

Barbieri M, Wickham D, Boehm J, Gulland F, Johnson S, Littnan C, Norris T, Rowles T, and **Simeone C.** Advancing Hawaiian monk seal conservation through collaborative approaches to malnourished animal transport, care and rehabilitation. Hawaii Conservation Conference, 2014. Oral presentation.

Simeone CA. Sick seals and seizing sea lions: what marine mammals can tell us about the health of our oceans. Marin Science Seminar, 2014. Oral presentation.

Simeone CA. Mapping marine mammal health: what marine mammals can tell us about the health of our oceans. Science Sunday at Seymour Center at Long Marine Laboratory, 2014. Oral presentation.

Simeone CA, Norris T, Palmer LJ, St. Leger J, Danil K, Chivers S, Berman M, Gulland FMD. 2014. Marine mammal health map: Goals, vision, and results from pilot study using data from California stranding responders. Proceedings from the International Association of Aquatic Animal Medicine Annual Conference. Oral presentation.

Simeone CA, Levine G, Barbieri M. Conservation medicine in endangered Hawaiian monk seals. Proceedings from the International Association of Aquatic Animal Medicine, 2014. Oral presentation.

Simeone CA, Gulland FMD, Norris T, Palmer L, St. Leger J, Danil K. 2014. Data integration of marine mammal health map. California Stranding Network Annual Meeting. Oral presentation.

Simeone CA, Nollens H, Meegan JM, Schmitt T, Jensen ED, Papich M, Smith, CR. 2013. Pharmacokinetics of single-dose oral meloxicam in bottlenose dolphins (*Tursiops truncatus*). International Association of Aquatic Animal Medicine Annual Conference. Oral presentation.

Simeone CA, St. Leger J, Nollens H, Schmitt T. 2013. Thyroid carcinoma in a Yellowbar angelfish (*Pomacanthus maculosus*). International Association of Aquatic Animal Medicine Annual Conference. Poster presentation.

WORKSHOPS/COMMITTEES

International Stranding Response Working Group. International Whaling Commission. 2015 – present. Convenor.

Cetacean Emerging and Resurging Diseases Working Group. International Whaling Commission. 2014 – present. Steering committee.

International marine mammal stranding toolkit workshop. Woods Hole Oceanographic Institution, 2014. Workshop planning committee.

Marine mammal health map: Scoping workshop for western states. Sausalito, California, 2014. Workshop planning committee.

Advances in care for rehabilitating marine mammals. Workshop, California Stranding Network Annual Meeting, 2014. Workshop chair.

JOURNAL REVIEWER

Polar Biology
Aquatic Mammals
North Pacific Research Board
Journal of Wildlife Diseases

PROFESSIONAL MEMBERSHIPS

International Association of Aquatic Animal Medicine
International Whaling Commission
American Cetacean Society
Wildlife Disease Association
Society for Marine Mammalogy

TERRIE M. WILLIAMS
Wildlife Eco-physiologist
Distinguished Professor of Ecology and Evolutionary Biology
Center for Ocean Health – Long Marine Laboratory
130 Shaffer Road, University of California-Santa Cruz, CA 95060
(831) 459-5123, williams@biology.ucsc.edu

EDUCATION

1988-89	University of California, San Diego: Certificate Program in Molecular Biotechnology.
1981-84	Scripps Inst. Oceanography – UCSD, San Diego, CA, Post-doctoral study (Physiology-G. Kooyman- mentor)
1981	Rutgers University, New Brunswick, NJ, Ph.D. (Environmental and Exercise Physiology, T.M. Casey-mentor)
1979	Rutgers University, New Brunswick, NJ, M.S. (Physiology)
1976	Douglass College, New Brunswick, NJ, B.A. (Biology, Graphic Arts)

EMPLOYMENT

2001-present	Professor of Ecology and Evolutionary Biology, University of California, Santa Cruz Antarctic Field Program- Hunting Behavior and Navigation Physiology of Weddell Seals Arctic Field Program – Physiology of Narwhals, Energetics of Polar Bears Marine Field/Lab Program- Cardiovascular Physiology and Energetics of Endangered Pinnipeds and Cetaceans; Carnivore Field/Lab Program- Foraging Behavior and Energetics of African lions, mountain lions and Alaskan wolves
1997-01	Associate Professor of Biology, University of California, Santa Cruz Antarctic Field Program- Hunting Behavior and Physiology of Weddell Seals African Field Program: -Thermoregulation and Water Use by African Elephants Bahamas Field Program- Biomechanics and Thermal Biology of Diving Dolphins
1994-97	Assistant Professor of Biology, University of California, Santa Cruz
1993-94	Scientific Officer, Molecular, Cellular, and Environmental Biological Processes, Office of Naval Research, 800 N. Quincy, Arlington, VA
1993-94	Marine Research Physiologist, University of California, Santa Cruz, CA; Program Manager: Physiology of Diving in Marine Vertebrates. Collaborative program with NRaD (San Diego).
1990-93	Research Physiologist, NOSC Hawaii Laboratories, Kailua, HI; Program Manager: Thermal and Exercise Physiology of Cetaceans
1991-	Alaska Field Research, Ecological Energetics and Indices of Body Condition in Steller Sea Lions; Supported by National Marine Fisheries Service
1989-95	Research Physiologist, Exxon Valdez Oil Spill; Toxicological evaluation and field tests for assessing the effects of petroleum hydrocarbons on oiled wildlife.
1987-88	Africa Field Research, Isolating the origin of FIP virus in captive and wild cheetahs of South West Africa; Locomotor morphology, physiology and biochemistry of the African cheetah.
1987	Arctic Expedition, Hematological and Physiological Indices of Diving Capacity of Narwhals. (Joint Program with Canadian Fisheries Service).
1986-89	Research Associate, Sea World Research Institute, San Diego, CA; Program Manager: Swimming mechanics and energetics of marine animals. Skeletal muscle physiology in diving birds and mammals. Thermoregulation in sea otters (*Enhydra lutris*).
1985-87	Research Associate, San Diego Zoo Research Department, San Diego, CA. Research Projects: Skeleton maintenance in wild and captive cheetahs. Locomotor mechanics and

	energetics in birds and mammals. Thermoregulation in elephants.
1986	Alaska Expedition, Sea otter swimming speed and behavior during acoustic and olfactory stimuli; Supported by Minerals Management Service, Department of the Interior.
1983-84	NIH Individual Postdoctoral Research Trainee, Physiological Research Laboratory, Scripps Institution of Oceanography, La Jolla, CA. Research Projects: Cardiovascular and tissue oxygen adjustments during swimming in marine mammals.
1983-84	Antarctic Expedition, Benthic ecology of McMurdo Sound. (P.I. - Paul Dayton, Gerald Kooyman).
1981-83	NIH Postdoctoral Fellow, Physiological Research Laboratory, Scripps Institution of Oceanography, La Jolla, CA. Research Projects: Hydrodynamics and energetics of swimming in marine mammals; physiological effects of submerged swimming including cardiovascular and respiratory responses.
1983	Australia Expedition, Habitat variability of mammals and birds of Eastern Australia.

PROFESSIONAL ACTIVITIES, HONORS, AWARDS & GRANTS

MEMBERSHIP IN SOCIETIES

American Physiological Society
Society for Marine Mammalogy
Society for Integrative and Comparative Physiology
American Zoological Association
Research Fellow, Zoological Society of San Diego
Fellow, California Academy of Sciences
Explorer Fellow, Wings WorldQuest

PROFESSIONAL ACTIVITIES

2018- present	Board of Reviewers, Comparative Physiology for Science Magazine
2013- 2018	Associate Editor Proceedings of the Royal Society B: Biological Sciences
2006-2008	Associate Editor, Marine Mammal Science
2000-2006	Advisory Panel, NOAA-NMFS Steller Sea Lion Recovery Team
1996-1998	Secretary, Society for Marine Mammalogy
1989- present	Annual Workshop Organizer and Presenter, Mitigating the effects of oil on marine mammals
1981- present	Reviewer National Science Foundation, National Geographic, Science, Nature, PNAS, Journal of Experimental Biology, Polar Biology, Marine Mammal Science

GRANTS (recent)

2017- 2021	Office of Naval Research, Physiological Consequences of Flight Responses in Diving Mammals: Critical metrics for assessing the impacts of novel environmental stimuli on cetaceans and other marine living species
2018-2020	Howard Hughes Medical Institute, Thermal Safari: Undergraduate STEM program
2017-2019	Office of Naval Research, Marine Mammal Diving Physiology Workshop
2017-2019	Sea World-Bush Gardens – lion Energetics
2014-2018	NSF Polar Programs, Geomagnetic Navigation by Weddell Seals beneath the Antarctic Ice, (collaborative grant with R. Davis- Texas A&M University and L. Fuiman – University of Texas)
2013-2017	NSF DBIR, Energy Scavenging Collar for Animal Physiology and Ecology (ESCAPE), (collaboration with C. Wilmers – Environmental Studies and G. Elkaim, Computer

	Engineering)
2013-2016	Office of Naval Research, High Risk Behaviors in Marine Mammals: Linking behavioral responses to anthropogenic disturbance to biological consequences
2010-2014	NSF DBI, ANIMA (Accelerometer Network Integrator for Mobile Animals) (collaborative grant with C. Wilmers – Environmental Studies and G. Elkaim, Computer Engineering
2008-2012	NSF Polar Programs, Collaborative Research: Hunting in Darkness: Behavioral and Energetic Strategies of Weddell Seals in Winter (collaborative grant with R. Davis- Texas A&M University and L. Fuiman – University of Texas)
2006-2009	US Department of Education, Conservation Biology through GAANN: Practical Skills for Applied Coastal Ecology. Continuation of 2001-2004 grant.
2006-2008	National Center for Ecological Analysis and Synthesis, Conservation Planning for Ecosystem Functioning: Testing predictions of ecological effectiveness for marine predators (with D. Doak)
2005-2008	Office of Naval Research, Physiological and Biochemical Neuroprotection in Cetaceans: Are some marine mammal species safeguarded from emboli formation and barotrauma?

HONORS AND AWARDS

2019	August Krogh Distinguished Lectureship, American Physiological Society, Comparative and Evolutionary Section
2016	Rutgers-Cook College, Dennis M. Fenton Distinguished Graduate Alumni Award
2015	Distinguished Author, 2015 Campus Reads, Notre Dame High School, San Jose, CA
2014	Distinguished Visiting Scientist and Author, Boise State University, Boise, ID
2013	Distinguished Visiting Scientist, University of New South Wales, Sydney, Australia
2013	AAAS/Subaru Science Book and Film Prize (Winner- Young Adult Science Books) and
2011	Medal Finisher, Ironman Triathlon 140.6 Mile Competition, Coeur d'Alene, ID
2009	The Laurence Irving- Per Scholander Memorial Lecturer in Comparative Physiology
2007	Wings WorldQuest, Ocean Explorer Award
	Fellow Induction in the California Academy of Sciences
2006	USGS Antarctic Site Designation, Terrie Bluff, Antarctica honoring Weddell fieldwork
2004- 2006	International Union of Physiological Sciences, Chair in Diving Physiology
2004	Douglass College, Distinguished Achievement Alumni Award
2002	Discover Magazine 50 Most Important Women in Science
	UCSC Biological Sciences Instructor of the Year Award
2000-2003	Ida Benson Lynn Endowed Chair in Ocean Health, UCSC
1987-present	Fellow of the Zoological Society of San Diego
1983-84	NIH Individual National Research Service Award

PUBLICATIONS

In Review

Pagano, A.M, Cutting, A., Nicassio-Hiskey, N., Hask, A., and Williams, T.M. (2018) Energetic costs of aquatic locomotion in a subadult polar bear (for **Marine Mammal Science**).

Suraci, J, Frank, L., Oriol-Cotterill, A., Ekwanga, S, Williams, T., Wilmers, C. 2018. Behavior-specific habitat selection by African lions promotes coexistence with humans (for **Ecology**).

Papers Published

O'Brien, T.G., Kinnaird, M.E., Ekwanga , S., Wilmers, C., Williams, T.M., Oriol-Cotterill, A., Rubenstein, D., Frank, L.G. 2018. Resolving a conservation dilemma: vulnerable lions eating endangered zebras. **PLoS ONE** 13(8): e0201983. https://doi.org/10.1371/journal.pone.0201983.

Pagano, A. M., Carnahan, A.M., Robbins, C.T., Owen M.A., Batson, T., Wagner, N., Cutting, A. Nicassio-Hiskey, N., Hash, A., Williams, T.M. 2018. Energetic costs of locomotion in bears: is plantigrade locomotion energetically economical? **Journal of Experimental Biology** 221, jeb175372. doi:10.1242/jeb.175372

Pagano, A.M, Durner, G.M., Rode, K.D., Atwood, T.C., Atkinson, S.N., Peacock, E., Costa, D.P., Owen, M., Williams, T.M. 2018. High energy-high fat lifestyle challenges an Arctic apex predator, the polar bear. **Science** 359, 568-572, DOI: 10.1126/science.aan8677.

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Abstracts (note co-authored presentations by colleagues, post-doctoral researchers and graduate students generally not included in list)

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Williams, T.M. 2017. The great escape: How large, carnivorous mammals move out of harm's way. Plenary Speaker, International Mammalogical Congress, Perth, Australia, July, 2017.

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Bryce C.M., and Williams T.M. 2015 Locomotive costs of domestic canids: exploring breed specific energetic economy. Society for Integrative and Comparative Biology, Jan. 3-7, West Palm Beach, FL.

Williams, T.M., Wilmers, C., and Wolfe, L.L. 2013. Not-So-King-of-The-Mountain lions: high energetic costs of puma moving over uneven terrains. Invited speaker for the Symposium on Energetic Costs and Behavioral Patterns in Mammals. International Mammalogical Congress, Belfast, Ireland, August 2013.

Williams, T.M. 2013. Racing to extinction: the high physiological cost of flight responses in large mammalian predators. Invited speaker for the Symposium on Physiological Approaches to Conservation. International Mammalogical Congress, Belfast, Ireland, August 2013.

Williams, T.M. and Lindberg, D. 2013. Gut Instinct: Digestive capacity and the evolution of marine mammals. The Society for Integrative and Comparative Biology, San Francisco, CA, January 4 - 8.

Williams, T.M. 2012. The Energetic and Biomechanics of Mountain Lions. The Society for Integrative and Comparative Biology Charleston, SC, January 3 - 6.

Williams, T.M., Kendall, T., Richter, B., Berry, P., Noren, S., Fuiman, L., Farrell, E., and Davis, R.W. 2011. Predicting foraging hot spots for marine mammals: An eco-physiological perspective. The Society for Marine Mammalogy Abstracts. Tampa FL, November 26 - December 2.

Williams, T.M. 2010. Variability in the dive response in active marine mammals. Invited speaker, Diving Marine Mammal Gas Kinetics Workshop. Woods Hole MA, April 2010.

Williams, T.M. 2008. Physiology and energetics in marine ecosystems. Invited speaker and organizer for the Symposium on Physiological Basis of Ecosystem Health. Experimental Biology, April 5-9, San Diego, CA.

Williams, T.M. and Zavanelli, M. 2008. Natural neuroprotection in the brains of marine mammals: why swimming dolphins don't stroke. Society for Integrative and Comparative Biology. Jan 2-6, San Antonio, TX.

Williams, T.M. 2007. Natural neuroprotection in marine mammals. Physiological Ecology Meeting. June 1-3, White Mountain Research Station, CA.

Williams, T.M. 2006. Survival Physiology: Reassessing why big, fierce animals are rare. 2006 American Physiological Society Conference on Comparative Physiology. Invited Plenary Talk. Oct 8-11, Virginia Beach, VA.

Williams, T.M. 2006. Foraging energetics and behavior of large, mobile predators: The cost of a stroke, step or flap. Invited symposium speaker, Proceedings of the Cambridge Symposium in Honor of John Croxall, April 6-9, Cambridge, England.

Williams, T.M. 2006. The physiology of surfing. Invited symposium speaker, 53rd Annual meeting of the American College of Sports Medicine, May 31-June 3, Denver, CO.

Williams, T.M. Rutishauser, M., Dunkin, R., and Quihuis, D. 2005. Variability in cetacean energetics: Do killer whales really have "killer appetites?" 16th Biennial Conference on the Biology of Marine Mammals, Dec 12-16, San Diego, CA.

Williams, T.M. 2005. Energetic and thermal challenges at depth: The marine mammal's dilemma. Symposium on Cardiorespiratory Physiology of Diving: Extreme physiology at Depth. XXXV International Congress of Physiological Sciences, March 31-Ap 5, San Diego, CA.

Williams, T.M., and Yeates, L. 2004. The Energetics of foraging in large mammals: A comparison of marine and terrestrial predators. Proceedings of the 3rd International Congress on Comparative Physiology and Biochemistry, Aug 7-13, KwaZulu, Natal, South Africa.

Williams, T.M. 2003. The collapse of pinnipeds and sea otter populations in the North Pacific Ocean: An ecological legacy of industrial whaling? Plenary Speaker, 15th Biennial Conference on the Biology of Marine Mammals, Dec 14-19, Greensboro, NC.

Williams, T.M. 2002. The effect of behavior on physiological dive capacity in marine mammals: What

lies beneath. The Physiologist 45(4); 324.

Williams, T.M. 1999. Sink or swim strategies for low cost diving in marine mammals. American Zoologist 39(5): 4A.

Williams, T.M. and Hurley, W.C. 1999. Batteries not included: Marine mammal strategies for cost efficient underwater performance. Proceedings of the 11th International Symposium on Unmanned Untethered Submersible Technology (99-8-01).

Williams, T.M., and Yeates, L. 1999. Long-Term effects of oil contamination in Alaskan sea otters. Symposium on the Legacy of an Oil Spill – 10 years after the Exxon Valdez, pp. 20.

Williams, T.M. 1998. The evolution of cost efficient swimming in mammals. Physiological Ecology Meeting, Bishop, CA

Williams, T.M. 1996. Physiological specialization dictates cost efficient locomotion in mammals. American Physiological Society, Integrative Biology of Exercise, Vancouver, Canada.

Williams, T.M., LeBoeuf, B., Davis, R., Crocker, D., and Skrovan, R. 1996. Integrating behavior and energetics in diving marine mammals: New views using video technology. 5th European Conference on Wildlife Telemetry, Strasbourg, France.

Williams, T.M. 1995. Mammalian strategies for locomotor and energetic proficiency in the aquatic environment. Zool. Soc. of London, Regents Park, England.

Williams, T.M. 1995. Swimming energetics of marine mammals: Terrestrial mammals in wetsuits? 11th Biennial Conference on the Biology of Marine Mammals. Orlando, Florida.

Williams, T.M. 1993. Swimming and diving energetics of Bottlenose dolphins: Low cost locomotion by a thinking athlete. Am. Zoologist 33(4).

Williams, T.M., Shippee, S.F., Lawson, K.L., Chun, N.C., Friedl, W.A., and Haun, J.E. 1993. Non-steady swimming increases dive duration in Bottlenose dolphins. Tenth Biennial Conference on the Biology of Marine Mammals. Galveston, TX.

Williams, T.M., Davis, R.W., Castellini, M.A., Loughlin, T.R., Calkins, D.G., and Sease, J. 1993. The relationship between body condition and thermoregulatory costs in Steller sea lion pups. Tenth Biennial Conference on the Biology of Marine Mammals. Galveston, TX.

Williams, T.M., Friedl, W.A., and Haun, J.E. 1992. Assessing the Physiological Limits of Exercise Performance in Bottlenose Dolphins. The Physiologist 35(4):224.

Williams, T.M., Friedl, W.A., Haun, J.E., and Chun, N.K. 1992. Balancing Power and Speed in Bottlenose Dolphins (*Tursiops truncatus*). Recent Advances in Marine Mammal Science, The Zoological Society of London, England.

Williams, T.M., Friedl, W.A., and Haun, J.A. 1991. Swimming by Bottlenose dolphins (*Tursiops truncatus*): Odontocete Olympians or sedentary cetaceans. Ninth Biennial Conference on the Biology of Marine Mammals, Chicago, IL.

Kanatous, S., Williams, T.M., Tirpak, A.J., and Davis, R.W. 1991. Thermoregulation in pinnipeds: The heat recycling sea lion. Ninth Biennial Conference on the Biology of Marine Mammals, Chicago, IL.

Williams, T.M., Friedl, W.A., Fong, M.L., and Haun, J.E. 1991. Swimming in Bottlenose Dolphins (*Tursiops truncatus*): Aerobic and Anaerobic limits to Performance. J. Exp. Mar. Biol. 71(3):727-728.

Williams, T.M. and Friedl, W.A. 1990. Heat Flow Properties of Dolphin Blubber: Insulating Warm Bodies in Cold Water. Am. Zool. 30(4).

Williams, T.M. 1990. Evaluating the Long Term Effects of Crude Oil Exposure in Sea Otters: Laboratory and Field Observations. Symposium on the Effects of Oil on Wildlife, International Wildlife Research Council, Washington, DC, October 16-18.

Williams, T.M. 1990. Acute Toxicity and Pathology of Sea Otters and Harbor Seals Impacted by the Exxon Valdez Oil Spill. Southern California Academy of sciences, Dominguez Hills, CA, May 11-12.

Williams, T.M. 1990. Oil Spills and Information Flow. Panel Discussion, Pacific Outer Continental Shelf Region Information Transfer Meeting, Minerals Management Services, Santa Barbara, CA, May 7-9.

Williams, T.M., McBain, J., Wilson, R., and Davis, R. 1990. Clinical Evaluation and Cleaning of Sea Otters Impacted by the Oil Spill. Sea Otter Symposium USFWS, Anchorage, AK, April 17-19.

Williams, T.M. 1989. Acute Toxicity and Pathology of Crude Oil in Sea Otters and Seals of Prince William Sound: An Overview. Marine Mammal Conference, Pacific Grove, CA.

Williams, T.M. 1989. Acute Toxicity and Pathology of Spilled Prudhoe Bay Crude in Marine Mammals. Conference on the Alaskan Oil Spill and Human Health, NIEHS, July.

Williams, T.M. 1989. Marine Mammals: Limits to athletic performance during submergence. Invited lecture, International Union of Physiological Sciences, Helsinki, Finland, July.

Williams, T.M., and Martin, J. 1988. Adaptations of avian skeletal muscle for aquatic locomotion: Evidence from biopsies and P-NMR spectroscopy. Am. Zoologist 28(4).

Williams, T.M., Kooyman, G.L., and Croll, D.A. 1987. The Relationship between Metabolic Rate and Heart Rate of Swimming Harbor Seals. The Physiologist 30(4):189.

Williams, T.M. 1987. Respiratory and cardiovascular responses to exercise in harbor seals and sea lions. Workshop on Pinniped Energetics, December.

Williams, T.M., and Kastelein, R.A. 1987. Comparison of the insulation of California and Alaska sea otters. Marine Mammal Conference, December.

Kacirk, J.J., and Williams, T.M. 1987. A Method for the measurement of metabolic heat transfer from various body regions of ocean mammals (immersed). Cold Water Diving for Science Symposium, October.

Williams, T.M. 1986. Heart rate and voluntary breath-hold duration in swimming harbor seals. Am. Zoologist 26(4).

Williams, T.M. 1984. Energetics and hydrodynamic advantages of submerged swimming in sea otters. Am Zool. 24(3).

Williams, T.M., and Kooyman, G.L. 1983. Swimming locomotion of the sea otter (*Enhydra lutris*) and North America Mink (*Mustela vison*, Schreber). Twenty-ninth Congress of the International Union of Physiological Sciences, Sydney, Australia.

Williams, T.M., and Kooyman, G.L. 1983. Hydrodynamic and swimming performance characteristics of harbor seals (*Phoca vitulina*). Fifth biennial Conference on the Biology of Marine Mammals, Boston, MA.

Williams, T.M., Kooyman, G.L., and Davis, R. 1983. Breath-hold duration during sustained swimming in the harbor seal (*Phoca vitulina*). IUPS Satellite Symposium: Breath-hold diving and asphyxia, Port Stephens, Australia.

Williams, T.M. 1982. Thermoregulation during swimming in the mink, a semi-aquatic mammal. The Physiologist 25(4), 279.

Williams, T.M. 1980. A comparison of running and swimming energetics in the mink. Ann. Meeting, Am. Soc. Zoologists, Seattle, Am. Zool. 20(4), 909.

Williams, T.M. 1980. Energy metabolism of running minks in relation to speed and gait pattern. Am. Physiol. Soc., Toronto, The Physiologist. 23(4), 41.

Williams, T.M. 1980. Metabolism and heat storage in the North American Mink. Regional meeting, Division of Comparative Physiology. Am. Soc. Zool.

<u>Books</u>

Williams, T.M. 2012. *The Odyssey of KP2: An orphan seal, a marine biologist and the fight to save a species.* Penguin Press, NY. 300 pp. (hardcover, paperback in 2013).

Estes, J.A., Doak, D., DeMaster, D., Brownell, R. and Williams, T.M. (eds.) 2007. *Whales, Whaling and Ecosystems*. University of California Press, Berkeley, CA, 418 pp.

Williams, T.M. 2004. *The Hunter's Breath: On expedition with the Weddell Seals of Antarctica*. M. Evans and Co., Inc., New York. 289 pp.

Williams, T.M. and Davis, R.W. 1995. *Emergency Care and Rehabilitation of Oiled Sea Otters and Other Fur-bearing Marine Mammals*. University of Alaska Press, Fairbanks. 279 pp.

<u>Book Chapters (recent with 12 additional references available on request)</u>

Williams, T.M. 2018. Swimming. In: *Encyclopedia of Marine Mammals, 3*. B. Wursig, and J.G.M. Thewissen, K. Kovaks eds. Academic Press, San Diego, CA, pp. 971-979.

Estes, J.A., Tinker, M.T., Williams, T.M. 2017. Recent advances in the physiology, behavior and

ecology of sea otters. *In* Biology and Conservation of the Musteloids (badgers, otters, skunks, raccoons and their kin). Oxford University Press, Oxford.

Kitchener, A., Melero, C., Williams, T.M. 2017. Mustelid form and function. *In* Biology and Conservation of the Musteloids (badgers, otters, skunks, raccoons and their kin). Oxford University Press, Oxford.

Williams, T.M, Maresh, J. 2016. Exercise Energetics. In Marine Mammal Physiology: Requisites for ocean living. Castellini, M.A., and Mellish, J., eds. CRC Press, Boca Raton, FL, pp. 47-68.

Helm, R.C., Costa, D.P., DeBruyn, T.D., O'Shea, T.J., Wells, R.S., and Williams, T.M. 2015. Overview of Effects of Oil on Marine Mammals. In *Handbook of Oil Spill Science and Technology.* Fingas, M., ed. John Wiley & Sons, Inc. Hoboken, N.J., pp. 455-476.

Williams, T.M. 2009. Swimming. In: *Encyclopedia of Marine Mammals, 2*. W.E. Perrin, B. Wursig, and J.G.M. Thewissen, eds. Academic Press, San Diego, CA, pp. 1140-1147.

Williams, T.M. 2007. Physiological and ecological consequences of extreme body size in whales. In: *Whales, Whaling and Ecosystems*. Estes, J.A., Doak, D., DeMaster, D., Brownell, R. and Williams, T.M., eds. University of California Press, Berkeley, CA, pp. 191-201.

Williams, T.M. and Worthy, G. 2002. Anatomy and physiology: The challenge of aquatic living. In: *Marine Mammal Biology: An Evolutionary Approach*. A.R. Hoezel, ed. Blackwell Science Ltd. Blackwell Publishers, London. pp. 73-97.

Williams, T.M. 1998. Physiological challenges in semi-aquatic mammals: Swimming against the energetic tide. In: *Behavior and Ecology of Riparian Mammals*. N. Dunstone and M. Gorman, eds. Cambridge University Press, Cambridge, England. pp. 17-30.

Williams, T.M., Shippee, S.F. and Rothe, M.J. 1996. Strategies for reducing foraging costs in dolphins. In: *Aquatic Predators*. S. Greenstreet and M.L. Tasker, eds. Blackwell Science Ltd., London. pp. 4-9.

Williams, T.M., O'Connor, D.J., and Nielsen, S.W. 1995. The effects of oil on sea otters: Histopathology, toxicology and clinical history. In: *Emergency Care and Rehabilitation of Oiled Sea Otters.* T.M. Williams and R.W. Davis, eds. University of Alaska Press, Fairbanks. pp. 3-22.

Williams, T.M., Davis, R.W., McBain, J.F., Tuomi, P.A., Wilson, R.K., McCormick, C.R. and Donoghue, S. 1995. Diagnosing and treating common clinical disorders in sea otters. In*: Emergency Care and Rehabilitation of Oiled Sea Otters.* T.M. Williams and R.W. Davis, eds. University of Alaska Press, Fairbanks. pp. 59-94.

Williams, T.M., McBain, J.F., Tuomi, P.A. and Wilson, R.K.. 1995. Initial clinical evaluation, emergency treatments and assessment of oil exposure. In*: Emergency Care and Rehabilitation of Oiled Sea Otters.* T.M. Williams, and R.W. Davis, eds. University of Alaska Press, Fairbanks. pp. 45-58.

Tuomi, P.A., and Williams, T.M. 1995. Rehabilitation of pregnant sea otters and females with newborn pups. In: *Emergency Care and Rehabilitation of Oiled Sea Otters.* T.M. Williams and R.W. Davis, eds. University of Alaska Press, Fairbanks. pp. 121-132.

Williams, T.M. 1995. Wildlife triage. In: *Emergency Care and Rehabilitation of Oiled Sea Otters.* T.M. Williams and R.W. Davis, eds. University of Alaska Press, Fairbanks. pp. 155-158.

Williams, T.M., Antonelis, G.A. and Balke, J. 1994. Health evaluation, rehabilitation, and release of oiled harbor seal pups. In*: The Impact of the Exxon Valdez Oil Spill on Marine Mammals*. T. Loughlin, ed. Academic Press. San Diego, CA. pp. 227-242.

Williams, T.M. 1987. Approaches for the Study of Exercise Physiology and Hydrodynamics in Marine Mammals. In: *Marine Mammal Energetics.* T. Huntley, D. Costa, M. Castellini, and G. Worthy, eds. Marine Mammal Journal Special Publication. Lawrence, Kansas. pp. 127-145.

Popular Articles/Children's Books (other)

Markovics, J.L. (T.M. Williams consultant) 2009. Weddell Seal: Fat and Happy. Bearport Publishing, New York . 32 pp. (science for slow readers).

Rodriguez, A.M. (T.M. Williams consultant) 2009. Secrets of the Sleepless Whales. Enslow Publishers, Inc., Berkeley Heights, NJ. 48 pp.

Williams, T.M. 2003. Sunbathing in Antarctica: The Weddell seals of summer. Natural History magazine. NY

Williams, T.M. 2000. Cetacean Olympians in *Dolphins* (T. Cahill, ed.) National Geographic Society Press, Washington, DC. Pp. 187.

Williams, T.D, and Williams, T.M. 1996. The role of rehabilitation in Sea Otter conservation efforts. Endangered Species Update 13:50-52.

Williams, T.M. 1992. Tiger on a Treadmill. Ranger Rick 26(6):34-37.

Davis, T.M., and Williams, T.M. 1991. The saga of the Alaska Sea Otters. The World and I 6(3):314-319.

Williams, T.M. 1990. Evaluating the Long Term effects of Crude oil exposure in Sea Otters: Laboratory and Field Observations. Special Publication of International Wildlife Research. 13 pp.

Williams, T.M. 1988. Cetacean Olympians. Cetus 8(1):2-6.

Technical Reports

Williams, T.M., Ponganis, P, Fahlman, A. 2018. Report on the Current Stats and Future Directions of Marine Mammal Diving Physiology: Workshop proceedings. For the Office of Naval Research, 124 pp.

Steller Sea Lion Recovery Team (T.M. Williams member) 2006. Steller Sea Lion Recovery Plan. Report to the National Oceanic and Atmospheric Administration-NMFS Office of Protected Species. 284 pp.

Williams, T.M. and Davis, R.W. 1989. Research Projects at the Sea Otter Rescue Centers: A Preliminary Report. Exxon Environmental Report. 36 pp.

Davis, R.W., Williams, T.M., and Awbrey, F.T. 1988. Sea Otter Spill Avoidance Study. Minerals Management Service, OCS Study MMS 88-0051. 65 pp.

Williams, T.M. 1987. The energetics and biomechanics of running in felids and canids. Report to The Whitehall Foundation. 12 pp.

Williams, T.M., Kastelien, R., Davis, R., and Thomas, J. 1986. Procedures for cleaning sea otter fur contaminated with fresh or weathered crude oil: Thermal implications of contamination and cleaning . In *Sea otter spill mitigation study*. Report to Minerals Management Service, #MMS 86009 OCS Study, 218 pp.

Participation in Public Lectures or Forums and Invited Research Seminars

2019	Plenary speaker, August Krogh lecture, Experimental Biology Meeting, Orlando, FL, April 6-9
2018	Invited Symposium speaker, American Physiological Society, Comparative Physiology Meeting, New Orleans, LA, October 25-28
2018	Invited Speaker, Duke Marine Laboratory, NC, October 21-25
2017	Plenary speaker, International Mammalogical Meeting, Perth, Australia
2017	Invited speaker, Julius Thomas Hansen Lectureship Series, University of California-Berkeley, April 12-14.
2016	Plenary speaker, Society of Integrative and Comparative Biology, Portland, OR.
2015	Invited speaker- Campus Read Program, Boise State University, Boise, ID
2013	Invited speaker, International Mammalogical Meeting, Belfast, Ireland
2013	Distinguished Female Scientist/Visitor, University of New South Wales, Australia
2012	Sitka WhaleFest Invited speaker and public outreach teacher, Sitka, AK
	Invited Speaker, Oiled Wildlife Care Network Annual Workshop, Santa Cruz, CA
2009	Distinguished Ecologist Series, Colorado State University
	The Laurence Irving- Per Scholander Memorial Lecture Series Visiting Professor
2008	San Diego Zoological Society. Invited speaker in symposium, State of Endangered Species: Climate Change Wildlife Impacts
	Miller Institute Interdisciplinary Symposium Speaker, University of California- Berkeley
	The Art of Exploration, featured speaker, San Antonio, TX
2007	National Geographic Live, Invited speaker, Washington DC
2006	American College of Sports Medicine, invited speaker annual meeting
	Northwest Pacific Fisheries Research Council
2005	California Academy of Sciences, Biology Teacher's Symposium
	University of Wyoming, Laramie, invited speaker
2003	Florida Atlantic University, Boca Raton, invited speaker
	University of North Carolina, Wilmington, NC
2002	Eckland Biology Laboratory, McMurdo Station, Antarctica
	Duke University, Beaufort Laboratory
2001	Eckland Biology Laboratory, McMurdo Station, Antarctica
	Schweppe Invited Speaker, University of Texas, Corpus Christi, TX
2000	Scripps Institution of Oceanography, UCSC
	IBM Science and Technology Conference 2000
1999	Eckland Biology Laboratory, McMurdo Station, Antarctica
1998	University of Alaska, Fairbanks/Seward Sealife Center
	Office of Naval Research, Washington, D.C.

	Eckland Biology Laboratory, McMurdo Station, Antarctica
1997	University of Alaska, Fairbanks
	Eckland Biology Laboratory, McMurdo Station, Antarctica
1996	Navy Postgraduate School, Monterey, CA
	University of California, Davis Veterinary School
1995	Hopkins Marine Station
	University of Durham
	Zoological Society of London
1994	National Zoological Society, Washington, DC
	University of Maryland, Dept. of Zoology
	University of Aberdeen, Scotland
1993	University of California, Santa Cruz, Dept. of Biology
	Office of Naval Research
	Texas A&M University, Dept. of Marine Biology
1992	Zoological Society of London, England
	University of California, Davis Veterinary School
	University of Hawaii, Dept. of Zoology
	Scripps Institution of Oceanography, Physiological Research Lab
1991	University of Birmingham, Birmingham, England
	University of Hawaii Medical School
	University of Portland
	Seattle Aquarium
1990	Monterey Bay Aquarium
	Wildlife Rehabilitation Council, Washington, DC
	Minerals Management Service, ITM, Santa Barbara, CA
1989	National Institutes of Environmental Health, Seattle Meeting
	University of Las Vegas
	IUPS, Finland
	American Cetacean Society
	Scripps Institution of Oceanography
1988	University of Pennsylvania Medical School
	University of California, Santa Cruz
1987	UCSD Medical School
	University of San Diego
	San Diego State University
	Zoological Society of San Diego

Sampling of Scientific Expeditions and Field Work

2015-present	Mpala Research Station, Kenya, Energetics of African lions
2014-present	Greenland, Cardiovascular Physiology of Diving Narwhals
2014-present	McMurdo Station, Antarctica, Navigation in Weddell Seals
2008-2011	McMurdo Station, winfly; Hunting in Darkness by Weddell Seals
2007	South Africa and Namibia: Water Use by African Elephants
2004-2006	San Nicolas Island, CA; Energetics of Growth in California Sea Lions
	Grand Bahama Islands; Variability in the Dive Response of Bottlenose Dolphins
2005	Lopez Mateos, Mexico; Sampling of by-catch cetaceans
2004	Namibia, Field Sites for Physiological Studies of Large Mammals
2003	Adak Island, AK; Field work on marine mammal abundance
1997-2002	McMurdo Sound, Antarctica Expedition; Foraging Behavior and Physiology of Weddell

	Seals
1994-5	Grand Bahama Islands, Thermal Physiology of Bottlenose Dolphins
1990-1995	Aleutian Islands and Gulf of Alaska, Body Condition in Steller Sea Lions
1990-1994	Hawaiian Islands, Thermal Physiology of Warm Water Dolphins
1988-90	Valdez Alaska and Prince William Sound; Toxicological Effects of the Exxon Valdez Oil Spill on Alaskan Sea Otters
1985	Windhoek, Namibia; Body condition and running morphology of African Cheetahs

Graduate Students

Student	Department	Degree Program	Year	Co-Sponsor
Lillian Carswell	Biology	Ph.D.	2019-	
Jessica Kendall-Bar	Biology	Ph.D.	2017-	Costa
Jason John	Biology	Ph.D.	2014-	
Anthony Pagano	Biology	Ph.D.	2012-2018	
Caleb Bryce	Biology	Ph.D.	2011-2017	
Jessica Meir	Scripps IO	Ph.D.	2008-2014	Ponganis
Nicole Thometz	Biology	Ph.D.	2008-2014	Estes
Jennifer Maresh	Biology	Ph.D.	2006-2014	
Robin Dunkin	Biology	Ph.D.	2004-2013	
Daniel Monson	Biology	Ph.D.	2002-2009	Estes
Heather Mostman	Biology	Ph.D.	2002-2008	
Laura Yeates	Biology	Ph.D.	2000-2006	
Dawn Noren	Biology	Ph.D.	1997-2002	
Shawn Noren	Biology	Ph.D.	1997-2002	
Matt Rutishauser	Biology	Masters	1997-2001	
Jeanine Scaramozzino	Biology	Masters	1997-2000	
Scott Shaffer	Biology	Ph.D.	1996-2000	Costa
Dawn Noren	Ocean Sci	Masters (1997)	1995-1997	
Shawn Noren	Ocean Sci	Masters (1997)	1995-1997	
Randolph Skrovan	Ocean Sci	Masters (1998)	1995-1998	
Suzanne Kohin	Biology	Ph.D. (1998)	1994-1998	Ortiz
Scott Shaffer	Ocean Sci	Masters (1996)	1994-1996	
Elisif Brandon	Texas A&M	Ph.D.	1993-2000	Davis

Postdoctoral Fellows

Nicole Thometz	(2014)
Robin Dunkin	(2013)
Suzanne Kohin	(1998)
Shawn Noren	(2009)
Laura Yeates	(2009)
Robin Dunkin	(2013)

UCSC STUDENT MENTORING

16 Ph.D. students (3 current), 6 Masters students, 6 post-doctoral scholars, > 200 in lab undergraduate students in the Marine Mammal Physiology Program

NICOLE M. THOMETZ, PHD

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https://thometzlab.wixsite.com/thometzlab

EDUCATION

Ph.D.	Ecology & Evolutionary Biology. University of California Santa Cruz Advisors: Dr. Terrie M. Williams & Dr. James A. Estes	2014
B.S.	Biology; philosophy minor. University of Portland, Portland, OR	2008

PROFESSIONAL POSITIONS

Assistant Professor	Department of Biology, University of San Francisco	2017 - present
Research Associate	Institute of Marine Sciences, UC Santa Cruz	2017 - present
Postdoctoral Scholar	Institute of Marine Sciences, UC Santa Cruz Advisor: Dr. Colleen Reichmuth	2016 - 2017
Postdoctoral Researcher	Ecology & Evolutionary Biology Department, UC Santa Cruz Advisor: Dr. Terrie M. Williams	2014 - 2016

AWARDS, GRANTS, & HONORS

NOAA Alaska Pinniped Research Program FY2016 [redacted] PI: Colleen Reichmuth, Co-PI's: **Nicole M. Thometz** & David Rosen	2016 - 2019
NOAA Alaska Pinniped Research Program FY2015 [[redacted] PI: Colleen Reichmuth; Postdoc: **Nicole M. Thometz**	2015 - 2016
Chancellor's Dissertation-Year Fellowship [redacted]	2013-2014
NSF Doctoral Dissertation Improvement Grant [[redacted]	2012
Rebecca & Steve Sooy Graduate Fellowship [redacted]]	2012
National Geographic Young Explorers Grant [redacted]]	2011
Myers Trust Award [redacted]	2009

PROFESSIONAL SOCIETIES

Society for Integrative and Comparative Biology

Society for Marine Mammolgy

PEER-REVIEWED PUBLICATIONS

Thometz NM, Rosen DAS, **Hermann-Sorensen, H,** Russell, B., Reichmuth, CR (In prep) "*Seasonal energetics of ice-dependent Arctic seals reveal the metabolic consequences of different molting strategies.*" For submission to Journal of Experimental Biology.

Thometz NM, Rosen DAS, Reichmuth, CR (In prep) "*Environmental and ontogenetic effects on energy intake and allocation in spotted seals (Phoca largha).*" For submission to Aquatic Mammals.

Goertz, CEC, Reichmuth, C, **Thometz, NM,** Ziel, H, Boveng, P (2019) "*Comparative health assessments of Alaskan ice seals*." Frontiers in Veterinary Science. 6(4):1-15. doi: 10.3389/fvets.2019.0004

Thometz, NM, Dearolf, JL, Dunkin, RC, Noren, DP, Holt, MM, **Sims, OC, Cathey, BC,** Williams, TM (2018) "*Comparative physiology of vocal musculature in two odontocetes, the bottlenose dolphin (Tursiops truncatus) and the harbor porpoise (Phocoena phocoena).*" Journal of Comparative Physiology B. 188(1): 177-193. doi: 10.1007/s00360-017-1106-5.

Thometz, NM, Kendall, TL, Richter, B, Williams, TM (2016) "*The high cost of reproduction in sea otters necessitates unique physiological adaptations.*" The Journal of Experimental Biology. 219(15): 2260-2264. doi: 10.1242/jeb.138891.

Thometz, NM, Staedler, MM, Tomoleoni, JA, Bodkin, JA, Bentall, GB, Tinker, MT (2016) *"Trade-offs between energy maximization and parental care in a diving central place forager, the sea otter (Enhydra lutris)."* Behavioral Ecology. 27(5): 1552-1566. doi: 10.1093/beheco/arw089.

Thometz, NM, Williams, TM, Murray, MJ (2015). "*Ontogeny of oxygen storage capacity and diving ability in southern sea otters (Enhydra lutris nereis): Costs and benefits of large lungs.*" Physiological and Biochemical Zoology. 88(3): 311-327. doi: 10.1086/681019.

Williams, TM, Fuiman, LA, Kendall, TL, Berry, P, Richter, B, Noren, SR, **Thometz, NM**, Shattock, MJ, Farrell, E, Stamper, AM, Davis, RW (2015). *"Exercise at depth alters bradycardia and incidence of cardiac anomalies in deep-diving marine mammals."* Nature Communications. 6(6055): 1-9. doi: 10.1038/ncomms7055.

Thometz, NM, Tinker, MT, Staedler, MM, Mayer, KA, Williams, TM (2014). *"Energetic demands of immature sea otters from birth to weaning: Implications for maternal costs, reproductive behavior, and population-level trends."* The Journal of Experimental Biology. 217(12): 2053-2061. doi: 10.1242/jeb.099739.

Undergraduate author; Graduate student mentee

OTHER PUBLICATIONS

Noren, DP, Holt, MM, Dunkin, RC, **Thometz, NM**, Williams, TM (2017) *"Comparative and cumulative energetic costs of odontocete responses to anthropogenic disturbance*." Proceedings of Meetings on Acoustics. Acoustical Society of America. 27:1-12.

Thometz, NM (2014). *"Ontogeny of Energetic Demand and Diving Ability in the Southern Sea Otter (Enhydra lutris nereis) and Implications on Diving and Foraging Behavior."* Doctoral Dissertation. University of California, Santa Cruz.

Thometz, NM (2014) *"Sea Otter Motherhood: and you thought you had it rough?"* Friends of the Sea Otter Fall Newsletter, p. 6-7. www.seaotters.org.

Tinker, MT, Jessup, D, Staedler, M, Murray, M, Miller, M, Burgess, T, Bowen, E, Miles, K, Tomoleoni, J, **Thometz, NM**, Tarjan, L, Golson, E, Batac, F, Dodd, E, Berberich, E, Kunz, J, Bentall, G, Nicholson, T, Newsome, S, MacCormick, H, Melli, A, Johnson, A, Henkel, L, Kreuder-Johnson, C, Conrad, P (2013). *"Sea Otter Population Biology at Big Sur and Monterey California: Investigating the Consequences of Resource Abundance and Anthropogenic Stressors for Sea Otter Recovery"*. Final Report to California Coastal Conservancy and U.S. Fish and Wildlife Service. University of California Santa Cruz, CA. 242 pages.

SELECTED PUBLIC SPEAKING

Thometz, NM, Kendall, TL, Richter, BP, Williams, TW (2019) "Reproductive physiology and energetics of sea otters." Sea Otter Conservation Workshop XI, Seattle Aquarium, Seattle, WA.

Thometz, NM, Rosen, DAS, Reichmuth, CR (2019) "*Seasonal energetics of ice-dependent Arctic seals reveal the metabolic consequences of different molting strategies.*" Society for Integrative and Comparative Biology (SICB) Annual Meeting, Tampa, FL USA.

Tengler, M, Bryan, A, Reichmuth, CR, **Thometz, NM** (2019) "*Physiological development of locomotor muscles influence diving capacities in free-ranging bearded seals.*" Society for Integrative and Comparative Biology (SICB) Annual Meeting, Tampa, FL USA.

Thometz, NM, Reichmuth, CR, Rosen, DAS (2018) "*PHOCAS: Physiology and Health of Cooperating Arctic Seals.*" Alaska SeaLife Center - Ocean Science Symposium, Seward, Alaska.

Thometz, NM, Reichmuth, CR (2018) "*Physiological Adaptations for Diving in the Bearded Seal.*" Society for Integrative and Comparative Biology (SICB) Annual Meeting, San Francisco, CA USA. [Session Chair]

Thometz, NM, Reichmuth, CR, Russell, B, Rosen, DAS (2017) "*Comparative Energetics of Ringed, Bearded, and Spotted Seals."* 22nd Biennial Conference on The Biology of Marine Mammals, Halifax, Nova Scotia, Canada.

Thometz, NM (2017) "*Using physiological research to inform the conservation of marine mammals*." 'Science on Tap' monthly public science talk series, organized by the University of California Women in Science and Engineering, and hosted at The Crepe Place, Santa Cruz, CA.

Thometz, NM, Rosen, DAS, Reichmuth, C (2017) *"Patterns of Energy Intake in Captive Spotted Seals (Phoca largha) Provide Insight into Physiologically Sensitive Life-Stages*." Society for Integrative and Comparative Biology (SICB), Annual Meeting, New Orleans, LA.

Noren, DP, Holt, MM, Dunkin, RC, **Thometz, NM**, Williams, TM (2016) *"Comparative and cumulative energetic costs of odontocete responses to anthropogenic disturbance*." Fourth International Conference on the Effects of Noise on Aquatic Life, Dublin, Ireland.

Thometz, NM, Kendall, TL, Richter, BP, Williams, TW (2016) "*Reproductive energetics in the sea otter*." Southern Sea Otter Research Alliance Meeting, Santa Cruz, CA, USA.

Thometz, NM, Dunkin, RC, Noren, DP, Holt, MM Williams, TM (2016) "*Aerobic and Anaerobic Capacities of Sound Production Muscles in Two Odontocetes."* Society for Integrative and Comparative Biology (SICB) Annual Meeting, Portland, OR, USA. [Session Chair]

Thometz, NM, Kendall, TL, Richter, BP, & Williams, TW (2015) "*The metabolic roller coaster: Reproduction in sea otters (Enhydra lutris) necessitates unique physiological adaptations*." 21st Biennial Conference on The Biology of Marine Mammals, San Francisco, CA, USA.

Tinker, MT, **Thometz, NM,** *et al.* (2015) "*Between a rock (crab) and a sharp place: The curious conundrum of the southern sea otter, and some unexpected silver linings*." 21st Biennial Conference on The Biology of Marine Mammals, San Francisco, CA, USA.

Tomoleoni, JA, **Thometz, NM**, Staedler, MM, Tinker, MT (2015). "*A range wide examination of southern sea otter diving behavior using 15 years of TDR data."* 21st Biennial Conference on The Biology of Marine Mammals, San Francisco, CA, USA.

John, J, Blackwell, S, Heide-Jorgensen, MP, Southall, B, Friedlander, A, **Thometz, NM**, Williams, TM (2015) "*Measuring instantaneous energetic costs in highly maneuverable marine mammals*." 21st Biennial Conference on The Biology of Marine Mammals, San Francisco, CA, USA.

Dunkin, R, Noren, D, Holt, M, **Thometz, NM**, Williams, TW, Jeffress, J, Cranford T (2015) "*Using CT scans to estimate mass of sound producing muscles in odontocetes: Implications for scaling the cost of vocal modification*." 21st Biennial Conference on The Biology of Marine Mammals, San Francisco, CA, USA.

Williams, TW, Richter, B, Kendall, TL, Ribeiro-French, C, John, J, **Thometz, NM** (2015) "*Degrees of physiological freedom: A new analytical tool for determining 3-dimensional critical habitats for marine mammals.*" 21st Biennial Conference on The Biology of Marine Mammals, San Francisco, CA, USA.

Thometz, NM, Staedler, MM, Tomoleoni, JA, Tinker, MT (2015) *"Using Time-Depth Recorders to Identify Sources of Variation in Southern Sea Otter Diving Behavior throughout their Current Range."* Sea Otter Conservation Workshop IX, Seattle Aquarium, Seattle, WA.

Staedler, MM, **Thometz, NM**, Tomoleoni, JA, Tinker, MT (2015) *"Fourteen Years of Time-Depth Recorder Activity Budget Data in Southern Sea Otters."* Sea Otter Conservation Workshop IX, Seattle Aquarium, Seattle, WA.

Kendall, TL, Richter, BP, Ribero-French, C, **Thometz, NM**, Williams, TM (2015) *"The Marine Mammal Physiology Project at Long Marine Lab Sea Otter Program."* Sea Otter Conservation Workshop IX, Seattle Aquarium, Seattle, WA.

Thometz, NM, Richter, BP, Kendall, TL, Williams, TW (2015) *"Physiological Capacity for Diving in the Critically Endangered Hawaiian Monk Seal."* Society for Integrative and Comparative Biology (SICB) Annual Meeting, West Palm Beach, FL. [Session Chair]

Thometz, NM (2014) "*Energetic Demands of Immature Sea Otters from Birth to Weaning: Implications for maternal costs, reproductive behavior, and population-level trends."* UCSC Graduate Science Communication Program – Reporting and writing science course. Santa Cruz, CA. *INVITED SPEAKER

Kendall, TL, Richter, BP, **Thometz, NM**, Williams, TW (2014) *"Aerobic Dive Limits of Hawaiian Monk Seals: A Physiological Metric for Establishing Ideal Foraging Habitat for an Endangered Species."* 42nd Annual International Marine Animal Trainer's Association Conference, Orlando, FL.

Thometz, NM (2014) *"An Energetic Life History of the Smallest Marine Mammal: the Sea Otter."* PhD Defense Seminar, UC Santa Cruz, Long Marine Lab – Center for Ocean Health, Santa Cruz, CA.

Thometz, NM, Tinker, MT, Staedler, MM, Tomoleoni, JA, Williams, TM (2014) *"The Diving and Foraging Behavior of Sea Otters in Big Sur and Monterey, CA."* Southern Sea Otter Research Alliance Meeting, Santa Cruz, CA.

Thometz, NM, Tinker, MT, Staedler, MM, Williams, TM (2013) *"Diving and Foraging Behavior in Southern Sea Otters in Resource Limited Habitats: are sea otters pushing their physiological limits to survive?"* 20th Biennial Conference on The Biology of Marine Mammals, Dunedin, New Zealand.

Thometz, NM, Tinker, MT, Staedler, MM, Williams, TM (2013) *"Diving and Foraging Behavior in Southern Sea Otters in Resource Limited Habitats: are sea otters pushing their physiological limits to survive?"* The CA Student Chapter of the Society for Marine Mammology 2013 Meeting, Santa Cruz, CA.

Thometz, NM (2013) *"Ontogeny of Oxygen Storage Capacity and Diving Ability in Southern Sea Otters (Enhydra lutris nereis)."* California Department of Fish and Wildlife Lunchtime Seminar Series, Santa Cruz, CA. *INVITED SPEAKER

Thometz, NM (2013) *"Development of Diving and Foraging Ability in the Southern Sea Otter (Enhydra lutris nereis)."* University of California, Santa Cruz - Graduate Research Symposium, Santa Cruz, CA.

Thometz, NM (2013) *"Development of Diving and Foraging Ability in the Southern Sea Otter (Enhydra lutris nereis)."* Sea Otter Conservation Workshop VIII, Seattle Aquarium, Seattle, WA.

Thometz, NM & Williams, TM (2013) *"Ontogeny of Oxygen Storage Capacity and Diving Ability in Southern Sea Otters (Enhydra lutris nereis)."* Society for Integrative and Comparative Biology (SICB) Annual Meeting, San Francisco, CA.

Thometz, NM (2012) *"The Ontogeny of Metabolic Demands in Southern Sea Otters."* Southern Sea Otter Research Update Meeting, Santa Cruz, CA.

Thometz, NM (2011) *"Physiological Development of the Southern Sea Otter: implications for energetic demand, diving ability, and foraging ecology."* Sea Otter Conservation Workshop VII, Seattle Aquarium, Seattle, WA.

Thometz, NM (2011) *"Physiological Development of the Southern Sea Otter: Implications for energetic demand, diving ability, and foraging ecology."* Dissertation Proposal Defense Seminar, Long Marine Lab – Center for Ocean Health, UC Santa Cruz, CA.

Thometz, NM (2010) *"The Physiological Capacities of the Southern Sea Otter - Preliminary Data, Current Research, and Future Directions."* Southern Sea Otter Research Alliance Meeting, Santa Cruz, CA.

Thometz, NM (2009) *"Little Pup in a Big Ocean—The challenging lives of young sea otters and their journey to adulthood."* Sea Otter Awareness Week Seminar Series, CSU - Monterey Bay, CA. *INVITED SPEAKER

Thometz, NM (2009) *"Assessment of the Physiological Capacities of the Southern Sea Otter from Birth to Senescence." Monterey Bay Aquarium Lunchtime Seminar Series, Monterey, CA. *INVITED SPEAKER*

Thometz, NM & Williams, TM (2009) "Assessing aerobic capacity in immature sea otters: the challenge of transitioning to independent foraging." Southern Sea Otter Research Alliance Meeting, Santa Cruz, CA.

Undergraduate author; Graduate student mentee

SELECTED POSTER PRESENTATIONS

Reichmuth, C, **Thometz, NM,** Russell, B, **Hermann-Sorensen, H**, Rosen, DAS (2019). "*Molting Strategies and Seasonal Energetic Requirements of Spotted, Ringed, and Bearded Seals*." Alaska Marine Science Symposium (AMSS), Anchorage, AK.

Midkiff, BM, Dearolf, JL, Thometz, NM, (2019) "*Comparison of glycolytic metabolism in bottlenose dolphin (Tursiops truncatus) and harbor porpoise (Phocoena phocoena) vocal muscles*." Society for Integrative and Comparative Biology (SICB) Annual Meeting, Tampa, FL USA.

Ballard, EJ, Barrett, LM, Dearolf, JL, **Thometz, NM,** Bryan, A, Reichmuth, C (2019) "*Hybrid fibers in the bearded seal (Erignathus barbatus) longissimus dorsi muscle*." Society for Integrative and Comparative Biology (SICB) Annual Meeting, Tampa, FL USA.

Hartwick, M, Reichmuth, C, **Thometz, NM** (2019) "*Evaluating seasonal changes in body condition for spotted, ringed and bearded seals*." Society for Integrative and Comparative Biology (SICB) Annual Meeting, Tampa, FL USA.

Thometz, NM, Rosen, DAS, Reichmuth, C (2018) "*Ice Seal Energetics: Measuring seasonal changes in metabolism for ringed, bearded, and spotted seals.*" Alaska Marine Science Symposium (AMSS), Anchorage, AK.

Hermann-Sorensen, H, Ruscher-Hill, B, Tengler, M, Bryan, A, Reichmuth, C, **Thometz, NM** (2018) "*Aerobic and Anaerobic Properties of Bearded Seal Locomotor Muscle*." Society for Integrative and Comparative Biology (SICB) Annual Meeting, San Francisco, CA USA.

Barrett, LM, Dearolf, JL, **Thometz, NM**, Bryan, A, Reichmuth, CR (2018) "Fiber-type composition of bearded seal (Erignathus barbatus) locomotor muscle." Society for Integrative and Comparative Biology (SICB) Annual Meeting, San Francisco, CA USA.

Thometz, NM, Rosen, DAS, Russell, B, Reichmuth, C (2017) "*Patterns of Energy Intake and Metabolism in Spotted Seals (Phoca largha) Provide Insight into Physiologically Sensitive Life-Stages*." Alaska Marine Science Symposium, Anchorage, AK.

Goertz, C, Tuomi, P, Woodie, K, Belovarac, J, Rouse, N, **Thometz, NM,** Reichmuth, C (2017) "*Clinical findings from stranded ice-dependent Arctic seals."* Alaska Marine Science Symposium, Anchorage, AK.

Soo, EM, Dearolf, JL, **Thometz, NM**, Dunkin, RC, Williams, TW, Noren, DN, Holt, MM (2017) "*Myosin heavy chain expression of cetacean vocal muscles.*" Society for Integrative and Comparative Biology (SICB), Annual Meeting, New Orleans, LA.

Goertz, C, Tuomi, P, Woodie, K, Belovarac, J, Rouse, N, **Thometz, N,** Reichmuth, C (2016) *"Clinical findings from stranded ice-dependent Arctic seals."* National Marine Animal Health and Stranding Network Conference, West Virginia, USA.

Goertz, C, Casper, D, Johnson, S, **Thometz, N**, Reichmuth, C (2016) "*Baseline measures of health for ice-dependent Arctic seals.*" 47th Annual International Association for Aquatic Animal Medicine (IAAAM) Meeting and Conference, Virginia Beach, VA.

Reichmuth, CR, **Thometz, NM**, Rosen, D, Goertz, C (2016) "*Comparative measures of health and physiology for ice-dependent Alaskan Seals.*" Alaska Marine Science Symposium (AMSS), Anchorage, AK.

Williams, TM, **Thometz, NM**, Blackwell, S, John, J, Heide-Jorgenson, MP (2014) *"High Risk Behaviors in Marine Mammals: Linking biomechanics to cardiac variability in fast and slow swimmers."* Office of Naval Research (ONR) Marine Mammal & Biology Program Review, Alexandria, VA.

Thometz, NM, Williams, TM, Tinker, MT, & Staedler, MM (2011) *"A longitudinal assessment of the ecological implications of heightened energetic demands of immature southern sea otters (Enhydra lutris neres)."* 19th Biennial Conference on the Biology of Marine Mammals, Tampa, FL.

Undergraduate author; Graduate student mentee

STUDENT MENTORING

Thometz Lab Graduate Students:

Michelle Hartwick, MS Student (Biology)	Aug 2018 – present
Mariah Tengler, MS Student (Biology)	Jan 2018 – present

Thometz Lab Undergraduate Research Assistants:

Bensu Tangil, Biology Major, USF Class of 2020	Sept 2018 – present
Amanda Telfer, Biology Major, USF Class of 2020	Sept 2018 – present
Lexy Anderson, Biology Major, USF Class of 2020	Aug 2018 – present
Audrey Sun, Biology Major, USF Class of 2020	Feb 2018 – present
Esther Grady, Biology Major, USF Class of 2019	Oct 2017 – present

Graduate Student Mentoring & Committees:

Dennis Hicks, MS Student (Chemistry), USF	Aug 2018 – present
Madelene Shehan, MS Student (Biology), USF	Aug 2017 – present
Brandi Ruscher-Hill, MS Student (Ocean Sciences), UC Santa Cruz	Jan 2017 – present
Holly Hermann-Sorensen, MS Student (Ocean Sciences), UC Santa Cruz	Aug 2016 – present

Undergraduate Honors Thesis Committees:

James Hurst-Hopf, Biology Major, USF Class of 2018	Aug 2017 – June 2018

TEACHING EXPERIENCE

Courses Taught:

University of San Francisco: August 2017 - present

- BIOL 319: Ecology
- BIOL 105L: General Biology I Laboratory
- BIOL 315: Biology of Marine Mammals
- BIOL 316: Biology of Marine Mammals Laboratory
- BIOL 350: Comparative Animal Physiology

BIOL 351: Comparative Animal Physiology Laboratory

University of California, Santa Cruz: Sept 2008 - July 2017

BIOE 133: Exercise Physiology
BIOE 133L: Exercise Physiology Laboratory
BIOE 107: Ecology
BIOE 131: Animal Physiology
BIOE 131L: Animal Physiology Laboratory

Teaching Assistantships (UC Santa Cruz):

BIOE 107: Ecology (Lecture/Discussion Section)
BIOE 131: Animal Physiology (Lecture/Lab)
OCEA 01: The Oceans (Lecture/Lab)

Other Relevant Experience:

Institute for Science and Engineering Educators Jan-Oct 2015

Professional Development Program (PDP) A flexible, year-long program for scientists at the early stages of their careers. Participants attend teaching workshops, join design teams, and teach a program or course at the end of each year. The PDP focuses on inquiry based learning at the college level, with a special emphasis on equity and inclusion. Participants learn a variety of inventive teaching strategies that can be applied to a range of teaching venues and leave the program as highly trained, innovative, and reflective scientist-educators.

SELECTED MEDIA COVERAGE

"Sea otter mums' metabolic rate rockets." *Inside JEB*, The Journal of Experimental Biology. Published online August, 3 2016 by Kathryn Knight. http://jeb.biologists.org/content/219/15/2229.1

"The Demands of Sea Otter Motherhood Prove Costly". Nature World News. Published online June 16th, 2014 by Jenna Lacurci. http://www.natureworldnews.com/articles/7603/20140616/the-demands-of-sea-otter-motherhood-prove-costly.htm

"It's Tough to be a Sea Otter Mom". *Quirks & Quarks, CBC Radio*. June 14, 2014. http://www.cbc.ca/quirks/2014/06/14/2014-06-14-2/

"It's hard being a sea otter mom." *ScienceNews.org*. Published online June 13, 2014 by Sarah Zielinski. https://www.sciencenews.org/blog/wild-things/it%E2%80%99s-hard-being-sea-otter-mom

"Sea Otter Moms Risk Lives to Raise Babies." *National Geographic*, Weird & Wild Blog. Published online June 11, 2014 by Katie Langin. http://newswatch.nationalgeographic.com/2014/06/11/sea-otters-animals-science-oceans-mothers-babies-young/.

"Raising young can be lethal for sea otters." *Science News*, SCIENCESHOT. Published online June 11, 2014 by Nadia Whitehead. http://news.sciencemag.org/biology/2014/06/raising-young-can-be-lethal-sea-otters

"Motherhood is no picnic for sea otter mums." *Inside JEB*, The Journal of Experimental Biology. Published online June 11, 2014 by Kathryn Knight. http://jeb.biologists.org/content/217/12/2029.2

"Where have all the otters gone? Decimated by the fur trade of the past centuries, the southern sea otter population has never fully recovered. UCSC scientists are piecing together the reasons why." *UCSC Magazine* Fall 2013. Published online Oct. 13, 2013 by Lily Dayton. http://news.ucsc.edu/2013/10/rev-fall-13-otters.html.

SELECTED SCIENTIFIC EXPEDITIONS AND FIELDWORK

Sarasota Dolphin Research Project (SDRP), Chicago Zoological Society - Sarasota, FL May 2015

As a postdoctoral researcher, I assisted in the annual field effort for the SDRP. Over a two-week period, we captured bottlenose dolphins and conducted health assessments in Sarasota Bay, Florida. More than 30 research projects were conducted concurrently. I participated as a field team member of Dr. Dan Costa's lab (UC Santa Cruz) providing logistical support and field assistance for bioenergetics studies.

USGS/UCSC Diablo Canyon Sea Otter Captures - San Luis Obispo & San Simeon, CA Oct 2012

As part of a collaborative field effort, I assisted in capturing, tagging, and instrumenting (VHF transmitters & TDRs) sea otters along the CA coast from San Luis Obispo to San Simeon. This was part of a 3-year monitoring project headed by the U.S. Geological Survey. Collaborating institutions included UC Santa Cruz, US Fish & Wildlife, Monterey Bay Aquarium, California Department of Fish & Wildlife, and UC Davis.

Weddell Seal Physiological & Behavioral Research - McMurdo Station, Antarctica Aug-Oct 2010

As PhD student, I participated in a collaborative field study in Antarctica examining the physiology, behavior, and energetics of Weddell seals. Our goal was to study the at sea foraging behavior and physiology of these animals as they foraged in complete darkness under the Ross Ice Shelf, Antarctica. This project was led by Dr. Terrie Williams (UC Santa Cruz), Dr. Randall Davis (Texas A&M University), and Dr. Lee Fuiman (University of Texas Austin). Funding and logistical support were provided by the National Science Foundation and the United States Antarctic Program (USAP).

USGS/UCSC Sea Otter Research Cruise - Big Sur, CA Nov 2008

As part of a collaborative field effort, I assisted in capturing, tagging, instrumenting (VHF transmitters & TDRs), and tracking sea otters off the coast of Big Sur, CA. This field effort was part of a 3 year monitoring program of southern sea otters off the central coast of California. This project was headed the U.S. Geological Survey and collaborating institutions included - UC Santa Cruz, Monterey Bay Aquarium, California Department of Fish and Wildlife, and UC Davis.

OTHER RELAVENT EXPERIENCE

Center for Ocean Solutions - Short Course on Ocean Policy - Monterey, CA Aug 2013

This course was co-taught by Meg Caldwell and Dr. Larry Crowder and hosted by the Center for Ocean Solutions and Stanford University. Space was limited and the application process was highly competitive. It introduced graduate students in the natural and social sciences to ocean policy and governance in the United States at national, regional, state, and local levels. We examined pressing issues in ocean sustainability from natural science, social science, and legal and policy perspectives, with an emphasis on the role of science in the policy and governance processes.

Lab Safety Representative – Williams Lab, UC Santa Cruz June 2011-April 2016

Responsibilities: Conduct regular safety inspections and ensure the lab meets all safety requirements.

Marine Mammal Physiology and Energetics Research Nov 2008-Present

I have been involved in a number of physiological and energetics focused research projects on a variety of marine mammal species over the duration of my career. The major data collection techniques for these projects have been open-flow respirometry, biochemical muscle tissue analyses, hematological analyses, accelerometer analyses, and behavioral examinations. Selected studies include: ontogeny of energetic demand in sea otters, metabolic demands of Weddell seals in the Antarctic winter, energetic cost of sound production in cetaceans, metabolic cost of swimming, diving, and molting in the Hawaiian monk seal, the energetic cost of gestation and lactation in sea otters, and quantifying the energetic demands of ice-dependent Arctic seals (ringed, bearded, and spotted).

Extensive Experience Conducting Marine Mammal Dissections July 2008-Present

I have conducted necropsys and dissections on a wide variety of marine mammal species, both for my own research and for educational purposes, throughout my career. Species I have worked with include: southern sea otter, harbor porpoise, bottlenose dolphin, northern elephant seal, northern fur seal, California sea lion, killer whale, humpback whale, and grey whale.

PUBLIC SERVICE ACTIVITIES & OUTREACH

Guest Polar Scientist Judge, Polar – ICE, Middle School Science Fair March 2018
California State University Monterey Bay, Monterey, CA

Public Science Talk – *Science on Tap*, UC Women in Science and Engineering July 2017
The Crepe Place, Santa Cruz, CA

Sea Otter Research Booth Volunteer - Coastal California NightLife Event Sept 2015
California Academy of Sciences, San Francisco, CA

Guest Speaker – Seymour Center Feb 2015
Docent Training Course, Santa Cruz, CA

USGS Sea Otter Outreach Presenter - 6^{th} & 7^{th} grade classes Nov & Dec 2014
Lakeview Middle School, Watsonville, CA.

Guest Speaker - UCSC Graduate Science Communication Program Oct 2014
Course: Reporting and Writing Science

Sea Otter Research Booth Volunteer May 2012
USGS Open House – Menlo Park, CA

Graduate School Panelist - UC Santa Cruz May 2011
Course: Biology Senior Thesis Course

Guest Speaker - Aptos High School May 2009
Class: Marine Biology

Guest Speaker - University of Portland March 2009
Course: Marine Biology of the Pacific Northwest

Science Fair Guest Judge April 2009
Santa Cruz Middle School, Santa Cruz, CA

Pacific Marine Mammal Center Volunteer - Laguna Beach, CA 2004-2008
Rescue and rehabilitation of marine mammals along the California coast.

USF SERVICE ACTIVITIES

Faculty Mentor, University Scholars Program
College Curriculum Committee
Biology Graduate Program Committee

Dr. M. Tim Tinker, Research Biologist
Curriculum Vitae
ttinker@nhydra.com, ttinker@ucsc.edu
http://werc.ucsc.edu/

Academic Record

University of California, Santa Cruz, CA
PhD Ecology and Evolutionary Biology, 1998-2004
Dissertation Research: Population biology and foraging behavior of the southern sea otter
University of Waterloo, Ontario, Canada
M.Sc., Biology, 1991-1993
Thesis: Behavioral ecology and energetics of grey seals (*Halichoerus grypus*) on land-fast ice
University of Guelph, Ontario, Canada
Honors B.Sc., Zoology, 1986-1990
Specialization: Wildlife Biology

Professional Appointments

- Adjunct Faculty, Department of Biology, Dalhousie University, Halifax NS, 2017- present
- Adjunct Faculty, Department of Geography, University of Victoria, Victoria BC, 2017- present
- Associate Adjunct Professor, UC Santa Cruz, Ecology and Evolutionary Biology, 2008 - present
- Research Scientist, US Geological Survey, Western Ecological Research Center, 2008 - 2017
- Assistant Research Biologist, UC Santa Cruz, Ecology and Evolutionary Biology, 2007-2008
- Post-doctoral researcher, UC Santa Cruz, Ecology and Evolutionary Biology, 2004-2007

Primary Publications

Chinn, SM, DH Monson, MT Tinker, MM Staedler, DE Crocker. (in press). Lactation and Resource Limitation Affect Stress Responses, Thyroid Hormones, Immune Function and Antioxidant Capacity of Sea Otters (*Enhydra lutris*). Ecology and Evolution.

Burgess, Tristan L., M. Tim Tinker, Melissa A. Miller, James L. Bodkin, Michael J. Murray, Justin A. Saarinen, Linda M. Nichol, Shawn Larson, Patricia A. Conrad, Christine K. Johnson. (in press). Defining the risk landscape in the context of pathogen pollution: *Toxoplasma gondii* in sea otters along the Pacific Rim. Royal Society Open Science

Gagne, Roderick; Tinker, M; Gustafson, Kyle; Ralls, Katherine; Larson, Shawn; Tarjan, L; Miller, Melissa; Ernest, Holly. 2018. Measures of effective population size in sea otters reveal special considerations for wide-ranging species. Evolutionary Applications, Early Ed. https://doi.org/10.1111/eva.12642

Silliman, Brian. R., Brent B. Hughes, Lindsay C. Gaskins, Qiang He, M. Tim Tinker, Andrew Read, James Nifong, John R. Stepp. 2018. Are the ghosts of nature past haunting conservation today? Current Biology 28(9): R532-R537

Nicholson, T. E., Mayer, K. A., Staedler, M. M., Fujii, J. A., Murray, M. J., Johnson, A. B., Tinker, M. T. and Van Houtan, K. S. 2018. Gaps in kelp cover may threaten the recovery of California sea otters. Ecography, doi:10.1111/ecog.03561

Kenner, M.C. and M.T. Tinker 2018. Stability and change in kelp forest habitats at San Nicolas Island. Western Naturalist. 78(4): 1-11

Hessing-Lewis, M., Rechsteiner, E.U., Hughes, B.B., Tinker, M.T., Monteith, Z., Olson, A., Henderson, M.M., Watson, J.C. 2017. Ecosystem features determine seagrass community response to sea otter foraging. Marine Pollution Bulletin. doi: 10.1016/j.marpolbul.2017.09.047.

Estes, J.A., M.T. Tinker and T.M. Williams. 2017. Advances in the physiology, behavior and ecology of sea otters. In “Biology and Conservation of Musteloids”, David W Macdonald, Christopher Newman and Lauren A Harrington (eds), Oxford University Press, Oxford, UK, ISBN-13: 9780198759805

Tinker, M.T., J.L. Bodkin, M. Ben-David and J.A. Estes. 2017. “Otters”. In Encyclopedia of Marine Mammals, 3rd Edition., Wursig, B., H. Thewissen, and K. Kovacs (eds), Elsevier Inc., NY, ISBN 9780128043813, pg. 664-671 of 1488 pp.

Estes, J.A. and M.T. Tinker. 2017. “Rehabilitating sea otters: feeling good vs. being effective.” In Effective Conservation Science: Data Not Dogma. Kareiva, P., Marvier, M. and Silliman, B. (eds). Oxford University Press, UK, ISBN: 9780198808985, 384pp

Tinker, M.T., and Hatfield, B.B., 2017, California sea otter (Enhydra lutris nereis) census results, spring 2017: U.S. Geological Survey Data Series 1067, 9 p., https://doi.org/10.3133/ds1067

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Tinker, M.T., K.M. Kovacs, M.O. Hammill. 1995. Behavior and energetics of male gray seals (Halichoerus grypus) breeding on landfast ice. Behavioral Ecology & Sociobiology 36:159-170

Professional Activities

<u>Research Positions:</u>

- 2017-present: Research Ecologist, Nhydra Ecological, Halifax, Nova Scotia
- 2008- 2017: Principal Investigator, USGS Santa Cruz Field Station of the Western Ecological Research Center. Lead scientist in studies of sea otter population biology and near-shore ecology
- 2000-2007: Co-Principle Investigator for long-term, telemetry-based study of sea otter demography and foraging ecology in California. Supervisor: Dr. James Estes

<u>Teaching Positions</u>

<u>Courses Taught:</u>

- Quantitative Ecology (BioE 148): Upper level undergraduate/graduate course on quantitative methods of analysis and modeling in ecology. UC Santa Cruz, CA, Spring 2010, 2012, *2014, 2015*
- Readings in Ecology (BioE 293): Core Graduate Course in Ecology and Evolutionary Biology, UC Santa Cruz, CA, 2008
- Regular Guest Lectures for UCSC courses: Kelp forest Ecology, Ecology of Marine Mammals, Disease Ecology, Conservation Biology, Field Methods in Biology, Community Ecology

<u>Graduate Students Advised</u>

- Sarah Espinosa M.Sc. student, UCSC
- Sarah McKay-Strobel, Ph.D. student, UCSC

- Kat Dale, Ph.D. student, UCSC
- Lily Tarjan, Ph.D. graduate, UCSC
- Ben Weitzman, M.Sc. graduate, UCSC
- Jessica Fujii, M.Sc. graduate, UCSC
- Holly MacCormick, M.Sc. graduate, UCSC
- Michelle Staedler, M.Sc. graduate, UCSC
- Lillian Carswell, M.Sc. graduate, UCSC
- Gena Bentall, M.Sc. graduate, UCSC

Graduate Student Committee Memberships

- Rodrigo Beas, Ph.D. student, UCSC
- Robin Dunkin, Ph.D. student, UCSC
- Jason Hassrick, Ph.D. student, UCSC
- Kristen McCully, M.Sc. student, UCSC
- Kim Brewitt, Ph.D. student, UCSC
- Nicole Thometz, Ph.D. student, UCSC
- Justine Smith, PhD student, UCSC
- Joseph Stewart, PhD student, UCSC
- Mary Young, Ph.D. student, UCSC
- Chris Law, PhD student, UCSC
- Joshua Smith, PhD student, UCSC
- Zach Hoyt, Ph.D. student, UA-Juneau
- Nathan Stewart, Ph.D. student, UAF
- Jackie Lindsey, Masters Student, MLML
- Emily Golson, Masters Student, MLML
- Tristan Burgess, PhD Student, UC Davis
- Erin Rechsteiner, PhD student, U Victoria
- Wendel Raymond, Ph.D. student, UA-Juneau
- Ben Weitzman, PhD student, UAF
- Jessica Hale, PhD student, U. Washington
- Megan Moriarty, PhD Student, UC Davis
- Tracy Grimes, M.Sc. student, San Diego State University
- Zach Randell, Ph.D. student, OSU
- Taylor Gorham, Dalhousie university

Post Doctoral Students Advised or Co-Advised

- Dr. Mark Novak, UCSC, 2011-13
- Dr. Brent Hughes, UCSC, 2014-16

Workgroup and Committee Memberships:

- Invited panelist for international symposium and review of tool-use in non-human animals, convened by University of Oxford, UK, August, 2015
- Invited expert reviewer and participant in Marine Mammal Research Program Review by Canadian Department of Fisheries and Oceans, Ottawa, Ontario, Canada, October 2014
- Invited expert panelist on Alaska Sea Grant and University of Alaska Fairbanks sponsored outreach forum to Alaskan communities to discuss sea otter – human interactions. Juneau, Alaska, May, 2014
- Invited expert panelist and participant in Canadian workshop to review ecological and social impacts of sea otter recovery, sponsored by Pew Fellowships. British Columbia, Canada, June 2014.
- Invited expert panelist for US Fish and Wildlife Service and University of Alaska Fairbanks Symposium on southeast Alaska sea otter recovery, Juneau, Alaska, February, 2013
- Invited expert witness for the black abalone recovery team (NMFS), August 2013
- Invited expert witness for hearings convened by the Federal Marine Mammal Commission (June 2013)
- Member of Southwest Alaska Sea Otter Recovery Team (SWAKSORT) convened by US FWS
- Invited participant, Marine Mammal Commission symposium to advise on the use of population viability analysis in marine mammal populations. Savannah, GA, Sept 2005 (report requested by US Congress)
- Invited participant, Marine Mammal Commission symposium to determine the ecological role of killer whales in the north Pacific. Seattle, WA, Apr. 2005 (report requested by US Congress)
- Invited participant, US Fish and Wildlife Service workshop to develop long-term monitoring plan for sea otters in south-west Alaska. Anchorage, AK, Feb. 2005.
- Invited participant, Alaska Sea Life Center/US Fish and Wildlife Service symposium to determine research priorities for the sea otter in south-west Alaska. Seward, AK, Apr. 2004.
- Invited participant, US Fish and Wildlife Service workshop to study sea otter decline in south-west Alaska. Anchorage, AK, Apr. 2002.
- Invited participant, National Center for Ecological Analysis and Synthesis working group on Ecosystem Based Management: Investigating the Roles of Top Predators, 2004-2007

Professional Society Memberships:

- Member of The Society for Marine Mammalogy, 1991-present
- Member of the Ecological Society of America, 2005-present

Journal Reviews and Editing

- Subject Editor, Ecological Applications (Nov 2013)
- Manuscript Reviews provided regularly (5-15 per year) for the following journals:
    - The American Naturalist
    - Ecology
    - Ecological Applications
    - Marine Mammal Science
    - Proceedings of the Royal Society
    - Journal of Animal Ecology
    - Can. J. Fisheries and Aquatic Science
    - Journal of Wildlife Management
    - Trends in Ecology and Evolution
    - Marine Biology
    - Oecologia
    - Animal Behavior
    - Population Ecology
    - Oikos
    - Marine Ecology Progress Series
    - Behavioral Ecology
    - Journal of Sea Research
    - Ecograophy
    - PLOS One
    - Proceedings of the National Academy of Science (PNAS)

Special Certifications and continued Professional Training:

- Completed Bayesian Statistics workshop, USGS-WERC, 2010: Bayesian inference for environmental scientists, ecologists and wildlife biologists
- Certified DOI Motorboat Operator (MOCC)
- First Aid/CPR certified (current) and trained in Wilderness First Aid

Grants, Awards and Scholarships

- National Science Foundation, 'Kelp forest community resilience in action' (co-PI, 2015-2018)
- Aleutian Bering Sea Islands LCC, 'Assessing effects of climate change and ocean acidification on sea urchin productivity and trophic interactions in the Aleutian Islands: Consequences for sea otter recovery' (PI, 2015-2016)
- US Navy, 'Sub-tidal Community Monitoring, San Nicolas Island' (PI, 2014-2015)
- US Fish and Wildlife Service, 'Aleutian Sea Otter Hot Spot Analysis' (PI, 2014-2014)
- California Coastal Conservancy, 'Sea Otter Habitat Use and Biology in Elkhorn Slough' (PI, 2013-2016)
- Oiled Wildlife Care Network, 'Developing a Network-based Tag for Sea Otter Monitoring' (PI, 2013-2016)
- US Fish and Wildlife Service, 'Sea Otter Ecology in Elkhorn Slough' (PI, 2013-2015)
- US Fish and Wildlife Service, 'Sea Otter Movements and Habitat Use' (PI, 2013-2014)
- US Fish and Wildlife Service, 'Sea Otter Population Analysis, SE Alaska' (PI, 2013-2014)
- Pacific Gas and Electric, 'Effects on Sea Otters of Seismic Surveys and Other Stressors' (PI, 2012-2014)
- US Fish and Wildlife Service, 'Modeling Sea Otter Range Expansion' (PI, 2012-2013)
- California Coastal Conservancy, 'Effect of Sea Otter Stressors, Big Sur and Monterey comparison ' (PI, 2011-2013)
- Department of Interior, 'Coastal Ecosystem Responses to Stressors from Land and Sea' (co-PI, 2010-2015)
- Bureau of Ocean Energy Management , 'Sea Otter Range Expansion in Southern California' (PI, 2010-2014)
- UC Davis/NSF, 'transmission dynamics of Toxoplasma gondii at the land-sea Interface ' (co-PI, 2010-2013)
- Alaska Sea Life Center, 'Report on Commander Island sea otter survey' (PI, 2010-2010)
- US Fish and Wildlife Service, 'Sea Otter Population Viability Analysis' (PI, 2009-2010)
- US Fish and Wildlife Service, 'Stressors Affecting Sea Otter Populations' (PI, 2008-2010)
- NPRB, 'NPRB Project 717, Causes of sea otter decline in SW Alaska' (co-PI, 2007-2010)
- UCSB MMS Coastal Marine Institute, 'Population Biology of Sea Otters at the South of their Range' (co-PI, 2000-2003)

- Research Grant from Friends of the Sea Otter: Development of a Spatially Explicit Population Model for the Southern Sea Otter, 2000
- Departmental Graduate Fellowship, Ecology and Evolutionary Biology Dept., UC Santa Cruz, 1998

Professional Technical Reports:

Tinker, M. T. et al., 2018. Sea otter monitoring plan for Gwaii Haanas National Park Reserve, National Marine Conservation Area Reserve and Haida Heritage Site. Final report for Parks Canada.

Tinker, M. T. et al., 2015. "Sea Otter Range Expansion and Habitat Use in the Santa Barbara Channel." Draft Final Report to the Bureau of Ocean Energy Management. US Geological Survey Project Report, 88 pages

Tinker, M. T., et al., 2013. "Sea Otter Population Biology at Big Sur and Monterey California: Investigating the Consequences of Resource Abundance and Anthropogenic Stressors for Sea Otter Recovery". Final Report to California Coastal Conservancy and U.S. Fish and Wildlife Service. US Geological Survey Project Report. 242 pages

Laird Henkel, Michael D Harris, Jack Ames, R Glenn Ford, Michelle Staedler, M Tim Tinker. 2014. Use of Decoys to Assess Effectiveness of Aerial Surveys for Sea Otters. California Department of Fish and Wildlife Office of Spill Prevention and Response Technical Report 14-2

Miller, M.A., Oates, S.C., Dodd, E,, Johnson, C.K., Tinker, M.T. 2014. Risk Factors for Shark Bite Mortality in Southern Sea Otters. Final Report for California Coastal Conservancy Agreement No. 20129034

Tinker, M.T. 2013. Appendix B: Southwest Alaska Distinct Population Segment of the Northern sea otter (Enhydra lutris kenyoni) Population Viability Analysis (PVA) Update. In USFWS (2013). Southwest Alaska Distinct Population Segment of the Northern Sea Otter (Enhydra lutris kenyoni), Recovery Plan 5-Year Review. Marine Mammals Management Office, US Fish and Wildlife Service.

Estes, J.A., J.L. Bodkin and M.T. Tinker. 2010. "Threatened southwest Alaska sea otter stock: delineating the causes and constraints to recovery of a keystone predator in the North Pacific Ocean". NPRB Project 717 Final Report

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Oftedal, O., K. Ralls, M.T. Tinker and A. Green. 2007. Nutritional constraints on the southern sea otter in the Monterey Bay National Marine Sanctuary, and a comparison to sea otter populations at San Nicolas Island, California and Glacier Bay, Alaska. Final Report to the Monterey Bay National Marine Sanctuary and the Marine Mammal Commission.

Tinker, M. T., J. A. Estes, K. Ralls, T. M. Williams, D. Jessup, and D. P. Costa. 2006. Population Dynamics and Biology of the California Sea Otter (Enhydra lutris nereis) at the Southern End of its Range. MMS OCS Study DRAFT REPORT. Page 351. MMS Cooperative Agreement Number 14-35-0001-31063. Coastal Research Center, Marine Science Institute, University of California, Santa Barbara, California.

GB Bentall, MT Tinker. 2006. The effect of the Moss Landing Power Plant thermal discharge plume on sea otter behavior and distribution. Report submitted to the Monterey Bay National Marine Sanctuary Integrated Monitoring Network (SIMoN) and Monterey Bay Sanctuary Foundation

Tinker, M.T., Estes, J.A., Doak, D.F. 2000. Development of a spatially explicit population model to assess potential population impacts associated with translocation of sea otters from south of Pt. Conception. Final report to Friends of the Sea Otter, October, 2000. Monterey, California.

Estes, J.A., Konar, B., Tinker, M.T. 1998. Sea Otter Population Biology and Subtidal Community Ecology at Shemya Island, Alaska. Final Report for Department of Defense Legacy Project Number 9401280 & 9510014

Tinker, M.T., Estes, J.A. 1997. Summary Report on Sea Otter Captures for Blood Contaminant Analysis and Collection of Population Data in the Western Aleutian Islands, 1997. Summary Report to the Navy, U.C. Santa Cruz, CA.

Tinker, M.T., Heaven, P.C., Ingham, L. 1997. Columbia Basin, Large Mammal Monitoring: 1994-97 Aerial Surveys, Final Report. Columbia Basin Fish and Wildlife Compensation Program, Technical Report

Tinker, M.T., Estes, J.A. 1996. The population ecology of sea otters at Adak Island, Alaska. Final Report to the Navy, Contract # N68711-94-LT-4026, U.C. Santa Cruz, CA.

Selected Talks and Presentations at Professional Meetings

Tinker. M. T. "Confessions of a Keystone Carnivore: complexity in food web interactions". Invited Seminar Speaker, Dalhousie University, Oct 2017 [Invited]

Tinker, M.T. "An Old Dog learns New Tricks from a Big Weasel: 25 Years of Sea Otter Research" Invited Keynote Speaker, Sea otter awareness week 2017, Seymour Center, Santa Cruz. Sept 2017.

Tinker. M. T. "Tool Use in Sea Otters" Presentation and Panel Participant, American Archaeology Society Annual International Conference, Vancouver, British Columbia, March 2017 [Invited panelist]

Tinker. M. T. "Confessions of a Keystone Carnivore: when simple trophic cascades go sideways ". Invited Seminar Speaker, Scripps Institute of Technology, Nov 2017 [Invited]

Tinker. M. T. "Complex food web interactions and diverse ecosystem effects of sea otters". Invited Seminar Speaker, Haida Fisheries Conference, Haida Gwaii, British Columbia, March 2016. [presentation] [Invited]

Tinker. M. T. "Sea Otter Ecosystem Function in alternative habitats". Invited Seminar Speaker, Moss Landing Marine Labs, California, April 2015. [presentation] [Invited]

Tinker. M. T. "Growth and Equilibrium in Sea Otters Re-visited: a new paradigm for sea otter conservation". Invited Plenary Presentation to Friends of the Sea Otter Special Event, Big Sur, CA, Sept 2015. [presentation] [Invited]

Tinker, MT, L Carswell, B Hughes, J Tomoleoni, B Weitzman, B Hatfield, J Estes, J Bodkin, K Ralls, L Bowen, K Miles, M Kenner, M Staedler, M Murray, A Johnson, B Kelly, S Espinosa, J Fujii, T Nicholson, K Mayer, M Miller, L Henkel, D Jessup, M Harris, J Ames, C Young, F Batac, E Dodd, T Burgess, C Johnson, P Conrad, K Shapiro, F Gulland, N Thometz, N LaRoche, L Tarjan, G Bentall, E Golson, S Newsome. 2015. Between a rock (crab) and a sharp place: the curious conundrum of the southern sea otter, and some unexpected silver linings. 21st Biennial Conference of the Biology of Marine Mammals: Bridging the Past to the Future, San Francisco, CA. 13-18 December 2015. [presentation] [Abstract]

Tinker, MT, B Hatfield, M Harris, J Ames. 2015. Exponential increase in rate of white shark attacks on sea otters in central California: demographic consequences and possible causes. 2015 American Fisheries Society Meeting, Santa Cruz, CA. 9 April 2015 [presentation] [Abstract] [Invited]

Tinker, M.T., Hughes, B. November 2014. Oral Presentation. From kelp forests to pickle weed: sea otter effects on ecosystem dynamics in two distinct coastal habitats. Invited Presented to the staff for Monterey Bay Aquarium's Conservation Science Seminar Series. [presentation] [Invited]

Tinker, M.T., J.A. Estes and J. L. Bodkin. 2013. "Effects of landscape and limited mobility on sea otter population recovery". Society for Marine Mammalogy, 20th Biennial Conference on the Biology of Marine Mammals, Dunedin, New Zealand. [presentation] [Abstract]

Tinker, M.T. and Novak, M. 2013. "Effects of time-averaged sampling on the inferred strength and temporal consistency of intraspecific diet specialization.". Invited speaker at Special Symposium : "Intra-population Niche Variation: From Incidence to Relevance ", 98th Annual Meeting of the Ecological Society of America, Minneapolis, MN, August 2013. [presentation] [Abstract] [Invited]

Tinker, M.T. 2013. "The sea otters of central California: keystone predators and indicators of near-shore ecosystem influences". Invited plenary speaker at "NRS day 2013: a celebration of the UC Nature Reserve System", Bren School of Environment, UC Santa Barbara, Feb 2013. [presentation] [Invited]

Tinker, M.T. 2013. "A paradigm coming of age? The promises, pitfalls and ontology of the Top-down system of thought in ecology". Invited plenary speaker for Presidential Symposium, Western Society of Naturalists Annual Meeting, Oxnard, CA, November 2013. [presentation] [Abstract] [Invited]

Tinker, MT, B Hatfield, M Harris, J Ames. 2013. Exponential increase in rate of white shark attacks on sea otters in central California: demographic consequences and possible causes. Sea Otter Conservation Workshop. March, 2013, Seattle, WA. [presentation] [Abstract]

Tinker, MT, B Hatfield, M Harris, J Ames. 2012. When the Shark Bites: Implications of Increasing White Shark Attacks for Southern Sea Otters. Southern Sea Otter Research Update Meeting. Feb 2013. Santa Cruz, California. [presentation] [Abstract]

Tinker, M.T., J.L. Bodkin, M. Staedler, D.H. Monson, B. Ballachey, K. Kloecker, G. Esslinger, H. Coletti, G. Bentall, J. Estes, O.T. Oftedal, K. Ralls, J. Tomoleoni, N. LaRoche, B. Weitzman, and J. Perry, 2011, Sea otter foraging ecology and energetics across populations. Sea Otter Conservation Workshop VII, March 2011, Seattle, WA. [presentation] [Abstract]

Tinker, M.T., Hatfield, B.B., Harris, M.D. and Ames, J.A.. 2011. "Increasing mortality from white shark attacks drives decline in southern sea otters: estimating demographic impacts using a spatially structured projection model". Society for Marine Mammalogy, 19th Biennial Conference on the Biology of Marine Mammals, Tampa, Florida. [presentation] [Abstract]

Tinker, M.T., Guimarães, P.R., Novak, M. 2011. "The structure and mechanisms of intraspecific diet polymorphisms". Invited speaker at Special Symposium "The Ecological Consequences of Intraspecific Variation ", 96th Annual Meeting of the Ecological Society of America, Austin, Texas, August 2011. [presentation] [Abstract] [Invited]

Tinker, M.T., and Novak, M. 2011. "Measuring temporal consistency of intraspecific diet specialization.". Invited speaker at special symposium, "Individuality in Marine Mammals. Society for Marine Mammalogy, 19th Biennial Conference on the Biology of Marine Mammals, Tampa, Florida.[presentation] [Abstract] [Invited]

Tinker, M.T. 2011. "Diets and Energetics Across Sea Otter Populations". 7th Annual International Workshop on Sea Otter Conservation, Seattle, WA. [presentation] [Abstract]

Tinker. M. T. "Causes and Sonsequences of Diet Specialization in Sea Otters". Invited Seminar Speaker, Moss Landing Marine Labs, California, May 2010. [presentation] [Invited]

Tinker. M. T. "Diet Specialization and Disease Exposure in Sea Otters". Invited Seminar Speaker, UC Davis Wildlife Epidemiology Class, California, February, 2010. [presentation] [Invited]

Tinker, M.T., J. Bodkin, M. Staedler, D. Monson, and G. Bentall, 2009, Using archival time-depth recorders to measure within- and between-population variation in diet and foraging success of sea otters. Carnivores Conference, Nov. 2009, Denver, CO. [presentation] [Abstract]

Tinker, M.T., Guimarães, P.R., Novak, M., Staedler, M.M., Bentall, G.B., Bodkin, J.L., Estes, J.A. Oct. 2009. Using network analysis to assess individual patterns of resource use: sea otters exhibit modularity at high density sites, providing evidence for a facultative diet polymorphism. Marine Mammal Society International Biannual Conference. Oct. 2009, Quebec City, Canada. [presentation] [Abstract]

Tinker, M.T., D. Monson, G. Esslinger, M. Staedler, J.L. Bodkin, 2009, Inferring reproductive and survival events from TDR data. Sea Otter Conservation Workshop VI, March 2009, Seattle, WA. [presentation] [Abstract]

Tinker, M.T., Christine Kreuder-Johnson, Melissa Miller, Dave Jessup, Jonna Mazet, Daphne Carlson Bremer,, Pat Conrad, James Estes. 2009. "Diet, density, disease and death in sea otters: implications for conservation and management." Carnivore Conference: Carnivore Conservation in a Changing World, Nov 2009, Denver, CO. [presentation] [Abstract]

Tinker, M.T., Bodkin, J., Staedler, M.M., Esslinger, G., Monson, D.H. May 2009 "Using core temperature records from biologging records to detect reproductive events." International sea otter conservation workshop, Seattle, WA. [presentation] [Abstract]

Tinker, M.T. Sept. 2009. Density-dependent diet diversification and individual differences in foraging behavior determine risk of disease exposure in southern sea otters. Society for Conservation Biology, Flagstaff, AZ. [presentation] [Abstract]

Tinker, M.T. Jan 2009. Using long term research on sea otters and kelp forest food webs to study the effects of climate change on coastal ecosystems. USGS/USFWS COASTAL CLIMATE CHANGE CONFERENCE FOR CALIFORNIA, OREGON AND WASHINGTON. San Francisco, CA. [presentation] [Abstract]

Tinker, MT. 2008. "Sea otter diets & population status: causes and consequences of individual foraging specializations" Invited Speaker at UC Santa Cruz EE Biology Seminar Series, June 2008: [presentation] [Invited]

Tinker, M.T., J. Bodkin, M. Staedler., G. Esslinger, D. Monson, G. Bentall, and M. Murray, 2008, Using TDR records to detect reproductive events in sea otters. International Biologging Conference, Sept. 2008, Pacific Grove, CA. [presentation] [Abstract]

Tinker, MT. 2007. "Sea otter diets & population status: causes and consequences of individual foraging specializations". Invited Speaker at Bodega Marine Laboratories Seminar Series, Jan 2007 [presentation] [Invited]

Tinker, M.T., G. Bentall, A. Burdin, and J.A. Estes. 2007. Ecological and behavioral responses to K: sea otters and kelp forest ecosystems in the Aleutian and Commander islands. 17th Biennial Conference on the Biology of Marine Mammals, Cape Town, South Africa. [presentation] [Abstract]

Tinker, M.T., C. Kreuder-Johnson, P. Conrad, M. Staedler, D. Jessup, J. Estes, M. Miller and J. Mazet. 2007. Linking Individual Behavior and Population Health: Tracking Protozoal Pathogen Exposure in Southern Sea Otters. 5th Workshop on Sea Otter Conservation, Seattle, WA. [presentation] [Abstract]

Tinker, M.T., C. Kreuder-Johnson. 2006. Linking Individual Behavior and population health: a multidisciplinary approach to predicting risk of disease exposure in sea otters. 20th Annual Meeting of the Society for Conservation Biology, San Jose, CA. [presentation] [Abstract]

Tinker, M.T., J.A. Estes, M.M. Staedler, J.L. Bodkin. 2005. Alternative diet specializations in the southern sea otter: energetic implications of a behaviorally-mediated foraging polymorphism. 16th Biennial Conference on the Biology of Marine Mammals, San Diego, CA. [presentation] [Abstract]

Tinker, M.T., D.P. Costa, J.A. Estes, N. Wieringa. 2005. Individual dietary specialization and dive behavior in the California sea otter: using archival time-depth data to detect alternative foraging strategies. 2nd International Bio-logging Science Symposium, St. Andrews, Scotland. [presentation] [Abstract]

Tinker, M.T., D.F. Doak, J.A. Estes. 2005. Effect of demographic variation and dispersal patterns at multiple spatial scales on the population recovery and range expansion of a threatened carnivore. 90th Annual Meeting of the Ecological Society of America, Montreal, Canada. [presentation] [Abstract]

Tinker, M.T., J.A. Estes, J.L. Bodkin, M.M. Staedler, and D.H. Monson, 2004, Studying sea otter foraging ecology: a review of some methodological approaches. Alaska sea otter research priorities workshop: Addressing the decline of the southwest Alaska sea otter population. April 2004, Seward, AK. [presentation] [Invited]

Tinker, M.T., Estes, J.A., Yeates, L., Staedler, M.M. 2002. Studying Sea otter Foraging Ecology. California and the World Ocean '02, Santa Barbara, CA [poster] [Abstract]

Tinker, M.T., Estes, J.A., Staedler, M.M., Bodkin, J. 2002. Sea otter Foraging Ecology: Sources of Variation in Dive Behavior, Diet and Foraging Success. Carnivores 2002 - From the Mountains to the Sea: A Conference on Carnivore Biology and Conservation, Monterey, CA. [presentation] [Abstract]

Tinker, M.T., Estes, J.A., Doak, D.F. 2000. A Model of Southern Sea Otter Population Dynamics and Range Expansion. Seventh Joint US-Russia Sea Otter Workshop, Monterey, California. [presentation] [Abstract]

Tinker, M.T., Doak, D.F. 2002. Southern Sea Otter Demography and Population Analyses. Carnivores 2002 From the Mountains to the Sea: A Conference on Carnivore Biology & Conservation, Monterey, CA. [presentation] [Abstract]

Tinker, M.T., Estes, J.A., Mangel, M. 2001. Individual variation in diet and feeding behavior of sea otters: cultural transmission of foraging skills contributes to the persistence of alternative foraging specializations. Invited Presentation at the Workshop on Culture in Marine Mammals, Fourteenth Biennial Conference on the Biology of Marine Mammals, Vancouver, British Columbia. [presentation] [Abstract]

Tinker, M.T., J.A. Estes, J.P. Watt, and D.H. Monson, 1999, A comparison of indices used to assess sea otter population status: scats may be worth a closer look. Biennial Conference, Biology of Marine Mammals, XIII, Wailea, HI. [presentation] [Abstract]

Tinker, M.T., Estes, J.A. 1997. Sea otter population decline in the western Aleutian Islands: an overview of trends, effects and possible causes. Sixth Joint US-Russia Sea Otter Workshop, Forks, Washington. [presentation] [Abstract]

Tinker, M.T., Estes, J.A. 1997. Is food-limitation causing the sea otter population decline at Adak Island, Alaska? Contrary evidence from activity budgets, diet and prey Size. Twelfth Biennial Conference on the Biology of Marine Mammals, Monaco. [presentation] [Abstract]

Tinker, M.T., Estes, J.A., Meehan, J. 1996. Demography, behavior and diet of sea otters at Adak Naval Reservation, Alaska. The Wildlife Society Third Annual Conference, Cincinnati, Ohio. [presentation] [Abstract]

Tinker, M.T., Kovacs, K.M., Hammill, M.O. 1993. Reproductive behavioral tactics of male grey seals breeding on landfast ice. Tenth Biennial Conference on the Biology of Marine Mammals, Galvaston, Texas. [presentation] [Abstract]

Curriculum Vitae

RAYMUND F. WACK M.S., D.V.M., Dipl. ACZM

A. Senior Veterinarian – Wildlife Health Center
School of Veterinary Medicine
University of California – Davis
1 Shields Avenue
Davis CA 95616-8747

Director of Veterinary Services
Sacramento Zoo
3930 West Land Park Dr
Sacramento CA 95822-1123
916-808-8808

B. Address [redacted]

Phone

E-mail rfwack@ucdavis.edu

C. Personal Information
Available upon request

D. Education

Date	Institution	Degree
1991	Ohio State University Veterinary Clinical Sciences Thesis: Response of Cheetahs to Routine Vaccination	Master of Science
1991	Ohio State University	Residency in Zoo Medicine
1987	Ohio State University	Doctor of Veterinary Medicine
1985	Ohio State University *Cum Laude* with Honors in the Liberal Arts with Distinction in Zoology.	Bachelor of Science

Educational Awards –
- 2018 UCDavis SVM Faculty Clinical Excellence Award
- 2010 Sacramento Zoo Summer Camp Teacher of the Week
- 1990 Telinject Graduate Research Award
- 1987 Raptor Rehabilitation Excellence Award
- 1986 Solvay Veterinary Student Award
- 1985 Phi Beta Kappa

E. Specialty Board Certification & Licenses

2017 Diplomat – European College of Zoological Medicine – Zoo Health Maintenance Specialty
1997 Diplomat - American College of Zoological Medicine - Zoo Medicine Specialty
State Veterinary Licenses: California, Ohio
DEA license, DEA Narcotics license (including ultra-potent narcotics)
USDA Accreditation

Training Activities
Senior Leadership Training Program – Empowering Performance Inc (2016-2017 Sacramento Zoo)

Amphibian Biology and Management – Professional Training Program AZA (2008)
24 hour Hazardous Waste Operations and Emergency Response (HAZWOPER) certification current

F. Professional Positions

Dates	Position/Title	Institution
Jan 2003 – present	Conservation Committee Chair	Sacramento Zoo
May 2001 – present	Chief of Service Zoo Medicine	UC Davis VMTH
Aug 2000 – present	Coordinator Zoo Med Residency	UC Davis/San Diego Zoo
Aug 2000 – present	Senior Veterinarian	UC Davis School of Vet Med
Aug 2000 – present	Director of Veterinary Services	Sacramento Zoo
May 1996 – Aug 2000	Director of Animal Health	Columbus Zoological Gardens
July 1991 – Aug 2000	Adjunct Associate Professor	Ohio State University
July 1991 - May 1996	Associate Veterinarian	Columbus Zoological Gardens
July 1988 - July 1991	Resident Zoo Medicine	Columbus Zoo & Ohio State Univ.
July 1987 - July 1988	Associate Veterinarian	Animal Clinic Northview

G. Teaching Experience

UCD VME 435C Zoological Medicine Block – SP semester 10 week course – 3 week subblock leader and lecturer 2017, Course coordinator 2014 – 2016. This intensive course immerses students in all aspects of zoological medicine by integrating classroom lectures, field trips, wet labs and student presentations. Course encompasses approximately 350 contact hours over the 10 week period. In addition to course coordination, I am primary instructor for 3 weeks of the 10 weeks and present approximately 15 hours of lecture plus lead 4 wetlabs/field trips. Evaluations are available.

UCD VMD Senior Clinics. Student enrollment 30- 40 students, student evaluations available. 2001 - present. As service chief for Zoological Medicine and staff veterinarian for the Sacramento Zoo, I teach senior veterinary students on the Zoo Med clinics rotation as well as instruct the first year zoo med resident. I am the program coordinator for the zoo med residency.

UCD Nutrition 115 –Animal Feeds and Nutrition Wi Qtr 4 units, 2009- present. Student enrollment 120. I teach a two hour lecture on Zoo and Wild Animal Nutrition for this Animal Science undergraduate class.

VME 493-042 Zoological Medicine Journal Seminar coordinator. I lead 1 hour weekly journal club for faculty and residents interested in Zoological Medicine. 2000 – present. Average 10 participants per week. Seminar is teleconferenced to San Diego Zoo and to former residents studying for ACZM boards.

VME 493-013 Avian Medicine Journal Seminar – Resident mentor – participate in weekly 1 hour journal club for faculty and residents interested in Zoological Companion Animal medicine. 2000 – present. Average 6 participants per week.

PMI 481R-001 Zoological Species Pathology Seminar – 2004 – present. Participant in twice monthly hourly seminar on pathology of zoological species based upon pathology materials submitted through the UCD VMTH Pathology Service. Average 16 participants across departments and campus units.

VSR 410R Zoological Species Radiology Seminar – Co-course coordinator. Monthly 1.5 hour seminar presenting imaging cases of zoological species. 2003 – present. Averages 8 participants including Radiology residents and faculty, CAPE residents and faculty, Zoo Med Residents and faculty, Primate Center Residents and faculty, northern California Zoological Institutions and UC system lab animal veterinarians.

UCD VME 410 Management of Captive Animals Sp Qt 2 units Course coordinator 2007- 2015

Lecturer 2004-2002 Student enrollment 20 – 60 students, student evaluations available. I taught 8 lectures in the course as well as coordinating the course.

UCD VME 415 Diseases of Captive Wildlife Fall Qt 2 units Course Coordinator 2005-2015 Student enrollment 20 – 50. Student evaluations available. I taught 6 lectures in the course as well as course coordination.

UCD VME 487 Comparative Anatomy and Physiology of Non-domestic Animals
Winter Qtr. Lecturer 2001- 2011. Course coordinator 2012 – 2015. Student enrollment 20 -60 students. Student evaluations available. I taught 5 lectures.

UCD VME 419 Companion and Exotic Small Animal Medicine and Surgery Fall Qtr 3.4 units 2003-2015. Student enrollment 20 – 80 students, student evaluations available. I taught 6 – 8 hours of lectures on reptile medicine and surgery.

PMI 418 Health and Disease in Terrestrial Wildlife WI Quarter. I taught a 2 hour lecture in Ecosystem Health Issues affecting Reptiles and Amphibians. 2008- 2015. 20 – 40 students. Evaluations available.

UCD PMI 419 Field Techniques for Assessment of Wildlife and Ecosystem Health Sp Qtr 2 units. Student enrollment 10 – 20 students. 2004 - 2012. My teaching involvement alternated between 8 hours on one day and 40 hours (5 days) of camping with the class in Southern California.

UCD VMD 490 Hospital techniques Wi Qtr 2003, 2002, 2001. Student enrollment 40 – 100. I organized and taught the reptile handling section of the lab (3 hours repeated 10 times during the quarter.

H. Audiovisual/Autotutorial Materials Developed

2016 Conservation Efforts and Impacts – Sacramento Zoo
2016 Acronyms and Abbreviations in Zoological Medicine
2016 Anesthetic Drugs and Combinations in Wildlife Medicine
2016 Medicine and Husbandry of Great Apes
2015 Clinical Pharmacology in Zoological Medicine
2015 Medicine and Husbandry of Prosimians and New World Primates
2015 Darting Equipment and Anesthesia Monitoring in Zoo and Wildlife Medicine
2015 Amphibian Medicine and Husbandry
2014 Introduction to Primate Medicine
2014 Animal Rights and Animal Welfare in Zoological Medicine
2014 Restraint and Handling Techniques in Zoological Medicine
2014 Clinical Pathology in Zoological Medicine
2014 Wildlife laws and Regulations
2013 Husbandry and Medicine of Bats
2010 Overview of Zoo Management Strategies
2010 Overview of Dentistry in Zoos
2008 Reptile and Amphibian Ecosystem diseases
2007 Preventative Medicine Programs in Zoos
2006 Diseases of Free-Ranging Reptiles and Amphibians
2005 Management and Husbandry of Fish
2005 Diseases of Felidae
2004 Diseases of Chiroptera
2004 Ethics in Zoos and wildlife
2004 The roles of Zoo and Wildlife Veterinarians
2004 Reptile Anatomy, Physiology and Husbandry
2004 Amphibian Anatomy, Physiology and Husbandry
2003 Diseases of Cheetahs
2003 Zoonotic Diseases of Captive Wildlife and Employee Health
2003 Diseases of Marine Mammals - Cetacea
2002 Diseases of Zoo Birds

2002 Diseases of Small Primates
2000 Pemphigus Foliaceus in a Hedgehog
2000 FIV in Captive Lions
2000 Management and Preventative Medicine in Cheetahs
2000 Infectious Diseases of Cheetahs
1999 Introduction to Ultrasound in Exotic Animals
1999 Interpretation of Clinical Pathology Data in Carnivores
1995 Water Quality Testing for Practitioners
1995 Internet Resources for Wildlife Vets - Multimedia
1995 Gill Function and Parasites of Freshwater Fish
1994 Amphibians - VME 608 core course
1994 Zoo Animal Case Studies
1992 Reptile Anesthesia and Chemotherapeutics
1992 Reptile Reproduction
1992 Diseases of Lizards, Turtles and Crocodiles
1991 Diseases of Amphibians & Reptiles
1991 Diseases of Native American Wildlife
1991 Diseases of Marine Mammals
1991 Avian Parasitology

I. Research Support

2018
Grant name: Phil and Karen Drayer Wildlife Health Center Fellowship Award
Project title: Pharmacokinetics of single-dose subcutaneous voriconazole in healthy Western pond turtles (Actinemys marmorata)
Investigators: Louden Wright, Jenessa Gjeltema, Ray Wack, Lisa Tell
Date: February 15, 2018- February 14, 2019
Amount of grant: $[redacted]
Funder: University of California Davis Wildlife Health Center

Project title: Pharmacokinetics of single-dose subcutaneous voriconazole in healthy Western pond turtles (Actinemys marmorata)
Investigators: Louden Wright, Jenessa Gjeltema, Ray Wack, Lisa Tell
Date: February 15, 2018- February 14, 2019
Amount of grant: $[redacted]0
Funder: Sacramento Zoo Conservation Fund

Grant name: Stoneybrook Farms/AZA Grant
Project title: Pharmacokinetics of single and multiple dose subcutaneous voriconazole in healthy Western pond turtles (Actinemys marmorata)
Investigators: Louden Wright, Jenessa Gjeltema, Ray Wack, Lisa Tell
Date: February 2018- February 2019
Amount of grant: [redacted]
Funder: Stoneybrook Farms

Grant name: Headstarting Giant Garter Snakes in the Natomas Basin
Investigators: Allie Essert, Brian Halstead, Ray Wack
Date: May 2018 – Dec 2018
Amount of grant: [redacted]
Funder: USGS New Dixon Station

2016
Evaluation of Blood Lactate Clearance in Live-Stranded Pinnipeds. Matt Marinkovich DVM, Ray F. Wack, DVM, Jenessa Gjeltema DVM, Cara Field DVM

Karen C Drayer Wildlife Health Center Fellowship Grant $4,993
Sacramento Zoo Conservation Fund Grant [redacted]

Assessing Temporal and Spatial Variation in the Fecundity and Health of Female Giant Garter Snakes (Thamnophis gigas) in response to Water Availability in the Sacramento Valley a six year survey. SPO Project Number 201700793. Ray F. Wack
USGS-CESU Grant Program [redacted]

2015
Detection of avian bornavirus in captive thick-billed parrots (*Rhynchopsitta pachyrhycha*) by RT-PCR and ELISA. Mary Thurber DVM, Ray F. Wack DVM, Nadine Lamberski DVM, Jenessa Gjeltema DVM
San Diego Zoo Collection Health Research Initiation Fund Grant $8,020
Sacramento Zoo Conservation Fund Grant [redacted]

Health survey and special ecology of Giant Garter Snakes in northern California. Ray F Wack, Brian Halstead
USGS University grants G15PX01336 [redacted]

2014
Comparison of 0.9% Saline and Amphibian Ringer's Immersions on Hematology and Plasma Chemistry Values in California Tiger Salamanders (*Ambystoma californiense*). Sean Brady DVM, Anne Burgdorf DVM, Ray F. Wack DVM.
Sacramento Zoo Conservation Fund Grant [redacted]

Radio telemetry and health survey studies in the Giant Garter Snake. Ray F Wack, DVM, Eric Hansen.
USBR Water Conservation Grant [redacted]

2013
Measurement of Acute Phase Proteins in Flamingos with Chronic Pododermatitis. Katie Delk DVM, Ray F. Wack, DVM
UC Davis Wildlife Health Center Fellowship [redacted]
Sacramento Zoo Conservation Fund Grant [redacted]
University of Miami Lab Grant $892

Ecology and conservation of the Giant Garter Snake in the Central Valley of California. Ray F. Wack, DVM, Eric Hansen.
USBR Water Conservation Grant [redacted]

2012
Population pharmacokinetics of a single subcutaneous dose of sustained release buprenorphine in northern elephant seals (*Mirounga angustirostris*). Christine Molter DVM, Ray Wack DVM.
Sacramento Zoo Conservation Fund [redacted]0
OWCN Research [redacted]5

Intraocular pressure in captive American Flamingo (*Phoenicopterus ruber*) as measured by applanation tonometry. Christine Molter DVM, Ray F. Wack, DVM, Sathya Chinnadurai DVM, Steven Hollingsworth DVM.
Sacramento Zoo Conservation Fund Grant [redacted]

[redacted] Central Valley of California. Ray F Wack, DVM, Eric Hansen.
Sacramento Area Flood Control Agency [redacted]

2011
Pharmacokinetics of Tulathromycin in the Desert Tortoise (Gopherus agassizii)
Raymund Wack, MS, DVM, DACZM, Matt Kinney, DVM, Nadine Lamberski, DVM, DACZM, Lisa Tell, DVM, PhD, DABVP (Avian), DACZM

Center for Companion Animal Health Grant [redacted]
Sacramento Zoo Conservation Fund Grant. $[redacted]

2010
Minimum anesthetic concentration of sevoflurane in captive thick-billed parrots (*Rhynchopsitta pachyrhyncha*) Kristen Phair, DVM, (Zoological Medicine Resident) R. Scott Larsen, DVM, MS, DACZM, Raymund Wack, DVM, MS, DACZM, Bruno H. Pypendop, DrMedVet, DrVetSci.
VMTH Resident Research Grant. [redacted]
Center for Companion Animal Health Grant [redacted]
Sacramento Zoo Conservation Fund Grant. $[redacted]

2009
[redacted] o-Investigators Ray F Wack, Eric Hansen Fecundity Study of Giant Garter Snakes in the Central Valley of California. Sacramento Area Flood Control Agency

Validation of Lactate Measurement in American Flamingo (*Phoenicopterus Ruber*) Plasma And Correlation With Duration and Difficulty of Capture. Anne Burgdorf, DVM, Kate Hopper, BVSc, DACVECC , Mike Ziccardi, DVM, Ph.D, R. Scott Larsen, DVM, MS, DACZM, Raymund Wack, DVM, MS, DACZM,
VMTH Resident Research Grant. [redacted]
Sacramento Zoo Conservation Fu[redacted]nt. [redacted]

2008
$[redacted] Co-Investigator Amanda M. White , E. Scott Weber, Raymund F. Wack, Principle Investigator R. Scott Larsen, Comparison of blood values and physiological parameters of 30 koi (*Cyprinus carpio*) using MS-222 and metomidate anesthesia. Center for Companion Animal Health.

[redacted] Co-Investigator Eric C. Hansen , Ray F. Wack, Robert H. Poppenga, DVM, PhD, DABVT, Christine Kreuder Johnson, VMD, MPVM, PhD. Implementation of Priority 1, Priority 2, and Priority 3 Recovery Tasks for Giant Garter Snake (Thamnophis gigas) – Comparative pathology, health, and contaminant exposure within San Joaquin Valley and Sacramento Valley giant garter snake populations. RFP # 08SF200001. Central Valley Conservation Program and Central Valley Project Improvement Act Habitat Restoration Program

2007
[redacted] Co-Investigator William Love, Raymund Wack. Efficacy of Commercial Rabies Vaccines in Captive Wild Felids. Sacramento Zoo Conservation Fund.

[redacted] Co-Investigator Jennifer Waldoch, Raymund Wack. Establishment of the Pharmacokinetic Parameters of Long Acting Ceftiofur in Chinese Goral. Sacramento Zoo Conservation Fund.

2006
[redacted] -Investigator Deena Brenner, DVM, R. Scott Larsen, DVM, MS, Dipl. ACZM, Raymund Wack, DVM, MS, Dipl. ACZM, Peter J Dickinson, BVSc, PhD, Dipl ACVIM (Neurology), Peter Pascoe, BVSc, DACVA, DVA, DECVA, MRCVS, Development Of A Brachial Plexus Nerve Block Technique For Perioperative Analgesia In Mallard Ducks. Center for Companion Animal Health (CCAH) Research Grant.

2005
[redacted] Co-Investigator – Julio Mercado, Scott Larsen, Bruno Pyendop , Ray Wack. Approximation Of The Minimal Anesthetic Concentration (MAC) Of Isoflurane In Captive Thick-Billed Parrots (*Rhynchopsitta pachyrhyncha*). Center for Companion Animal Health (CCAH) Research Grant, VMTH Resident Research Award.

2004
[redacted] Co-Investigator – Ray Wack, Cora Singleton, Scott Larsen, Frozen Meat Diet Quality Control and Safety. Sacramento Zoo, Columbus Zoo, 3M Microbiology Division

[redacted] – Ray Wack, Scott Larsen, Survey of blood lead and mercury levels in Giant Garter Snakes from the Central Valley of California, Conservation Fund of the Sacramento Zoo.

2003
[redacted] Co – Investigator, Evaluation of a Gamma Interferon Enzyme Immunoassay, a Multiple-Antigen ELISA, and an Antigen 85 Immunoassay for Screening for *Mycobacterium tuberculosis* Infection in Orangutans (*Pongo pygmaeus*) N. Boedeker, R. Scott Larsen, R Wack, Nicholas W. Lerche, M.D. Salman, JoAnn Yee, Michael Ziccardi, Funding source MAZURI Research Grant

2002
$[redacted] Investigator – Raymund Wack, Scott Larsen, Clinical Evaluation of an Avian Chemistry Rotor. Abaxis Corporation

2000
$[redacted] Co-Investigator – Raymund Wack, Grant Frazer, Ultrasonographic Imaging of the reproductive tract of the female Scimitar-Horned Oryx. OSU Columbus Zoo Co-Operative Research Grants.

$[redacted] Co-Investigator – Raymund Wack, Brad Coupe, Mate location in Sidewinder Rattlesnakes. OSU Columbus Zoo Co-Operative Research Grants.

1999
$[redacted] Investigator – Raymund Wack, Jerry Masty, A novel way to extend the educational missions of the Columbus Zoo and the College of Veterinary Medicine: Plastination. OSU Columbus Zoo Co-Operative Research Grants.

1998
$[redacted] Investigator – Raymund Wack, Disease Surveillance of Free-Living Waterfowl and Rodents and Their Potential Health Risks for Zoological Collections. OSU Columbus Zoo Co-Operative Research Grants.

$[redacted] Co-Investigator – Raymund Wack, Studies on the Ecology and Epidemiology of Meningeal Worm Infection as a Foundation for the Development of Control Strategies Applicable to Non-Domestic Ungulates. OSU Columbus Zoo Co-Operative Research Grants.

1997
$[redacted] Co-Investigator - Raymund Wack, Heart Rate Variability in Great Apes - A Pilot Study. OSU Columbus Zoo Co-Operative Grants.

1996
[redacted]0 Co-Investigator - Raymund Wack, Feline Immunodeficiency Virus as a Neurotropic Lentivirus in the Lion. OSU Columbus Zoo Co-Operative Grants.

1995
[redacted] MS Conservation Grant - Principle Investigator - Raymund Wack, Pooling of Medical Records and AAZV BBS

[redacted] o-Principle Investigator - Raymund Wack, Conservation, Reproductive Behavioral Ecology nd Population Genetics of the Timber Rattlesnake (*Crotalus horridus*) OSU / Columbus Zoo Co-operative Grants

[redacted] o-Principle Investigator - Raymund Wack, Comparison of the Electrocardiogram of Wild and Captive Wolves OSU / Columbus Zoo Co-operative Grants

[redacted] o-Principle Investigator - Raymund Wack, Plastination: A Unique Method of Preserving Animal Specimens for Education and Demonstration OSU/ Columbus Zoo Co-operative Grants

[redacted] o-Principle Investigator - Raymund Wack, Adsorption Spectra of Feline Hemoglobin in the Visible and Near Infrared Region OSU/Columbus Zoo Co-operative Grants

1993

$[redacted] Co-Principal Investigator - Raymund Wack, Bacterial Gastritis in Cheetahs OSU/Columbus Zoo Co-operative Grants

[redacted] Co-Principal Investigator - Raymund Wack, Further Characterization of a Unique Isolate of Feline Immunodeficiency Virus from Captive Lions OSU/Columbus Zoo Co-operative Grants

1992

[redacted] Principal Investigator - Raymund Wack, Systemized Infant Growth Rate Records - Columbus Zoo Enrichment Grants

1990

[redacted] Principal Investigator - Raymund Wack, Vaccination of Cheetahs OSU/Columbus Zoo Co-operative Grants

[redacted] Principal Investigator - Raymund Wack, Analysis of Zoo Diets OSU/Columbus Zoo Co-operative Grants

J. Publications: Refereed Journals – first author

2017. Wack, Ray F., Eric C. Hansen, Chris K. Johnson, and Robert Poppenga. Bacterial Flora of the Giant Garter Snake (*Thamnophis gigas*) and Valley Garter Snake (*Thamnophis sirtalis fitchi*) in the Central Valley of California. Western Wildlife 4:61-71.

2012. Wack, Raymund F., Eric Hansen, Marilyn Small, Robert Poppenga, David Bunn, And Christine K. Johnson. Hematology And Plasma Biochemistry Values For The Giant Garter Snake (*Thamnophis Gigas*) And Valley Garter Snake (*Thamnophis Sirtalis Fitchi*) In The Central Valley Of California *Jwildlifedis* 48:307-313.

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1989. Wack, Raymund F., D.V.M., Jamie G. Lindstrom D.V.M., David L. Graham. Internal Hydrocephalus in an African Grey Parrot. Journal of the Association of Avian Veterinarians.

1986. Wack, Raymund F., Robert L. Hamlin D.V.M. The Use of the Chicken Heart in a Langendorff Preparation. Laboratory Animal Science 36(2): 186-188.

Co – author

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2018. Amdoparvovirus infection in the red panda (*Ailurus fulgens*). Charles E. Alex, Steven V. Kubiski, Linlin Li, Reza Saghedi, Raymund F. Wack, Megan A. McCarthy Joseph B. Pesavento, Eric Delwart, Patricia A. Pesavento. Veterinary Pathology 55(4):552-56. https://doi.org/10.1177/0300985818758470

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2016. Hematology and Plasma Biochemistry Intervals for Captive-Born California Tiger Salamanders (Ambystoma Californiense). Sean Brady, D.V.M., Anne Burgdorf-Moisuk, D.V.M., Dipl. A.C.Z.M., Philip H. Kass, D.V.M., M.P.V.M., M.S., Ph.D., Dipl. A.C.V.P.M., Jacqueline Brady, D.V.M., and Raymund F. Wack, D.V.M.,M.S., Dipl. A.C.V.M. Journal of Zoo and Wildlife Medicine 47(3): 731–735.

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2015. Percutaneous Ureteral Stent Placement for the Treatment of a Benign Ureteral Obstruction in a Sumatran Tiger (*Panthera tigris sumatrae*) Katie W. Delk, Raymund F. Wack, Anne Burgdorf-Moisuk, Carrie A. Palm, Allison Zwingenberger, Craig B. Glaiberman, Kenneth H. Ferguson, and William T. N. Culp. Zoo Biology.

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D.V.M., M.S., Dipl. A.C.Z.M., Dipl. A.C.V.A.A., and Raymund F. Wack, D.V.M., M.S., Dipl. A.C.Z.M. Journal of Zoo and Wildlife Medicine 46(1): 52–6.

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K. Other Publications (Books, Book Chapters, Symposium, non-peer review)

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1995. Wack, Raymund F. Water Quality Testing for Practitioners. Annual Proceedings of WEZAM Exotics Conference, Madison WI

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1994. Wack, Raymund F., D.V.M., M.S. and Douglass Warmolts. Book Review of Fish Medicine by M. Stoskopf published in Copeia 1994 (2) 548-549.

1994. Wack, Ray F., D.V.M., MS, L. W. Kramer. An Unusual Presentation of Osteomyelitis in a Snow Leopard (*Panthera uncia*) Cub. 1994 Proceedings American Association of Zoo Veterinarians 1147-148.

1992. Wack, Ray F., D.V.M., L. Kramer D.V.M., M.J. King BS, M. Marr B.S., M. Lyons B.S., L. Lafrado Ph.D. Isolation and Preliminary Characterization of a Unique Feline Immunodeficiency Virus from a Captive Lion (*Panthera leo*). Proceedings of Joint Meeting of AAZV / AAWA p355-359 and poster presentation.

1992. Wack, Ray F., D.V.M., MS and D.I. Warmolts. Suspected Gas Bubble Disease in Captive Loggerhead Sea Turtles. Poster Presentation AAZPA National Conference.

1991. Wack, Ray F., D.V.M. The Vaccinations of Cheetahs. 1991 Proceedings American Association of Zoo Veterinarians p. 294-297.

1991. Wack, Ray F., D.V.M. Control of Avian Parasites. Midwest Avian Research Expo p61-64.

1990. Wack, Ray F., D.V.M., Lynn W Kramer D.V.M., William Cupps and Stacy Katz, B.S. Antibody Titer Response of Cheetah (*Acinonyx jubatus*) Cubs to Vaccination. 1990 Proceedings of American Association of Zoo Veterinarians. p . 147-149.

1990. Wack, Ray F., D.V.M., Lynn W Kramer D.V.M., William Cupps, Stacy Katz B.S.. Growth Rate of 21 Captive Mother-raised Cheetah Cubs (*Acinonyx jubatus*). Poster Presentation. Proceedings of the American Association of Zoo Veterinarians p. 308.

L. Faculty and Departmental Responsibilities

Jan 2014 – Present	UCDavis Clinical Education Committee	Zoological Medicine advisor
May 2001 – present	UC Davis Zoological Medicine Residency	Program Coordinator

January 2000 – present	UCDavis Zoological Medicine Service	Service Chief
August 2002 – present	UCDavis WAAM student club	Faculty Advisor
Oct 2001 – present	UCDavis SVM Zoo Med Track	Track Coordinator
March 2012 – 2016	UC Davis Zoological Medicine faculty search committee	
August 2002 – 2014	UCDavis SVM Track Coordination Committee Committee Member	
March 2005 – Nov 2005	UCDavis SVM wildlife clinician faculty search committee	
June 1995 – Aug 2000	Columbus Zoo Veterinary Preceptorship	Program Administrator
Jan 1993 – Aug 2000	VME 608 Course Planning Committee	Committee Member
July 1991 – Aug 2000	General Advising	Avg. 4 students per qtr.
July 1991 – Aug 2000	Student Chapter AAZV	Faculty Advisor

M. Other Service and Professional Assignments

Dates	Institution	Position/Title
October 2009 – present	ACZM	Chairperson Credentials Committee
May 2009 – present	AZA	Grevy Zebra SSP Veterinary Advisor
April 2003 – present	Sacramento Zoo	Conservation Committee Chairman
Jan 2000 – present	AZA	Accreditation Inspector
Jan. 2000 - present	ACZM	Credentials Committee
Dec 1994 - present	Zoo Biology	Review manuscripts for publication
Feb 1993 - present	Journal of AAZV	Review manuscripts for publication
Oct 1991 - present	AAZV	Information Resources Committee Member
May 2017	AZA	Miller Park Zoo Accreditation Inspection
May 2016	AZA	Jackson Zoo Accreditation Inspection
June 2015	ACZM	Hosted Strategic Plan retreat
Oct 2012	Ca DFW	Sea Otter capture and telemetry surgeries
June 2012	AZA	Zoo Boise Accreditation Inspection
Feb 2011	AZA	Alameda Zoo Accreditation Inspection
Oct 2011	AAZV	Carnivore Session Chair
Jul 2011	ACZM	Job analysis Strategic Retreat
Nov 2009	AZA	Santa Barbara Zoo Accreditation Inspection
Oct 2007	AAZV	Primate Session Chair
July 2007	AZA	Zoo Boise Accreditation Inspection
Feb 2006	AZA	Micke Grove Zoo Accreditation Inspection
Jan 2005	AZA	Micke Grove Zoo Accreditation Inspection
Jan. 2000 – 2008	AZA	Animal Health Committee
Oct 2002 – Sep 2003	AAZV	Nominations Committee Chairman
Oct 2002 – Sep 2003	AAZV	Ethics Committee Chair, Executive Board
Sep 2001 – Oct 2002	AAZV	President, Member of Executive Board
Sep 2000 – Sep 2001	AAZV	President-elect, Program Chair,
Oct. 1999 – Sep 2000	AAZV	Vice-President, Member of Executive Board
Oct. 1999	ARAV	Local Host for Annual Conference
Oct. 1999	AAZV	Local Host for Annual Conference
Oct. 1998 – Sep 1999	AAZV	Secretary, Member of Executive Board
Oct. 1997 - Sep 1998	AAZV	Treasurer, Member of Executive Board
Oct. 1997	AAZV	Anesthesia Section Chairman for Conference
Jan 1996 – Dec 1999	AAZV	World Wide Web Page Manager
July 1991 – Aug 2000	Columbus Zoo Committee Member	Conservation and Collection Management
Oct 1996 - Oct 1997	AAZV	Anesthesia Section Chair for 97 Conference
Aug 1995 - Mar 96	AVMA	Section Sysop NOAH/AAZV
Jan 1995 - Mar 96	ISIS	Zoo Vet BBS Sysop
Mar 1995 - Jan 96	Journal of AAZV	Special Issue Editor
Oct 1994 - Sep 96	AAZV	Executive Committee Member
Nov 1992 - Sep 96	AAZV	ISIS/Computer Data Committee Chairman
Feb 1991 - Jun 95	ARCAS	Veterinary Advisor for Rehab Center

N. Professional/Academic Association Memberships

Association of Avian Veterinarians (AAV)
American Association of Zoo Veterinarians (AAZV)
American College of Zoological Medicine (ACZM)
Association of Zoos and Aquariums (AZA)
Association of Reptile and Amphibian Veterinarians (ARAV)
American Veterinary Medical Association (AVMA)
Wildlife Disease Association (WDA)
The Wildlife Society (TWS)

O. Awards and Honors

2018 UCDavis SVM Faculty Clinical Excellence Award
2011 ACZM Presidential Service Award
2010 Sacramento Zoo Summer Camp Teacher of the Week
1999 AAZV Presidential Service Award
1997 AAZV Presidential Service Award
1996 AAZV Presidential Service Award
1995 AAZV Presidential Service Award
1994 AAZV Presidential Service Award
1987 SCAVMA Service Award
1985 SCAVMA Service Award
1976 Eagle Scout

P. International Experiences

Position/Title	Country	Dates
Mountain Gorilla Scientific Advisory Committee	Rwanda	2008 - Present
Ross Veterinary School	St. Kitts	May 2006
CBSG Veterinary Training Workshop	Chengdu China	December 1999
CBSG Captive Panda Health Assessment	Beijing China	March 1998
ARCAS Site Visit / Veterinary Advisor	Guatemala, CA	June 1995
Veterinary Advisor for ARCAS	Guatemala, CA	February 1993

Q. Selected Invited Presentations

Organization	Title of Presentation	Location and Date
AAZV/EAZV Conference	Amdoparvovirus discovery in red pandas	Prague, Czech Republic 2018
USGS/USFWS GGS Recovery	Healthy survey results for giant garter snakes	Elk Grove, CA Oct 2016
Tuleyome Wildlife Conservation	The role of Zoos in Wildlife Conservation	Davis, CA Nov 2016
Grevy Zebra SSP	Update on EHV-1 in zebra and bears	Memphis, TN 2014
Grevy Zebra SSP	Morbidity and Mortality Survey results	Chattanooga, TN 2012
Sacramento Dental Society	Dentistry in a Zoo Setting	Sacramento CA May 2010
C.L. Davis Comparative Pathology	Canine Distemper in Red Pandas (D. Montali presenter)	New Orleans LA Sep00
Association of OR Nurses	Diversity of Practice – Surgery Skills at the Zoo	Columbus OH Apr00
North Am. Vet. Conf.	Pemphigus in hedgehogs, FIV in Lions Management and Diseases of Cheetahs	Orlando FL Jan 00
Columbus Academy of Vet Med.	Zoo Medicine and Conservation	Columbus Zoo Nov 98

Cleveland Academy of Vet Med	Reptile Medicine (4 hrs)	Cleveland Zoo Oct 97
AAZV	Information Resources for Wildlife Vets	East Lansing MI Aug 95
Ohio State University	Reptile Medicine for Practicing Vets 12 hours of lectures	Columbus OH May 95
WEZAM	Water Quality Testing for Practitioners	Madison, WI Apr 95
WEZAM	Gill Function and Parasites	Madison, WI Apr 95
AAZV	Unusual Presentation of Osteomyelitis	Pittsburgh, PA Oct 94
AAZV	MedARKS Training Wetlab	Pittsburgh, PA Oct 94
Mid-Ohio Herpetologists	Wildlife Conservation in Guatemala	Columbus Zoo Jun 93
AAZV	FIV in Lions Poster	Oakland CA Nov 93
Mid Ohio Exotic Bird Club	Wildlife Conservation in Guatemala	Columbus OH Aug 93
Golden Crescent Cage Bird Club	Wildlife Conservation in Guatemal	Cleveland OH Jul 93
Mid Ohio Herpetologists	Sea Turtles - Scientific Presentation	Columbus Zoo Feb 93
AAZV/MedARKS	Mid-year meeting - organized mtg	Columbus Zoo Mar 93

R. Continuing Education Attended

2018 American Association of Zoo Veterinarians Annual Conference, Prague Czech Republic
2017 American Association of Zoo Veterinarians Annual Conference, Dallas, TX
2017 AZA mid-year meeting, Albuquerque, NM
2016 Atlantic Coast Veterinary Conference, Atlantic City NJ
2015 American Association of Zoo Veterinarians Annual Conference, Portland OR
2014 American Association of Zoo Veterinarians Annual Conference, Orlando, FL
2014 AZA mid-year meeting, Memphis TN
2013 American Association of Zoo Veterinarians Annual Conference, Salt Lake City, UT
2012 American Association of Zoo Veterinarians Annual Conference, Oakland CA
2011 AZA mid-year meeting, Chattanooga, TN
2011 Biosound Esoate Small Animal Ultrasound 16 hr course, San Luis Obispo CA
2011 American Association of Zoo Veterinarians Annual Conference, Kansas City MO
2010 American Association of Zoo Veterinarians Annual Conference, South Padre Island TX
2010 Zoos and Aquariums Committing to Conservation, Seattle WA
2009 American Association of Zoo Veterinarians Annual Conference, Tulsa OK
2008 Amphibian Biology and Management Profesional Training Program, Toledo OH
2008 American Association of Zoo Veterinarians Annual Conference, Knoxville TN
2007 Canine Medicine Symposium, UC Davis CA
2006 American Association of Zoo Veterinarians Annual Conference, Tampa FL
2006 California Veterinary Medical Association Annual Conference, San Francisco CA
2005 American Association of Zoo Veterinarians Annual Conference, Omaha NE
2005 UC Davis University Communications Media Training, Davis CA
2004 American Association of Zoo Veterinarians Annual Conference, San Diego CA
2004 Spring CE California Veterinary Medical Association, Yosemite CA
2003 Access 2000 level 1 software training, Sacramento CA
2003 American Association of Zoo Veterinarians Annual Conference, Minneapolis MN
2002 Excel 2000 level 2 software training, Sacramento CA
2002 American Association of Zoo Veterinarians Annual Conference, Milwaukee WI
2002 Association of Avian Veterinarians Annual Conference, Monterey CA
2001 American Association of Zoo Veterinarians Annual Conference, Orlando FL
2001 Association of Reptilian and Amphibian Veterinarians Annual Conference, Orlando FL
2000 American Association of Zoo Veterinarians Annual Conference, New Orleans LA
2000 North American Veterinary Conference, Orlando FL
1999 American Association of Zoo Veterinarians Annual Conference, Columbus OH
1998 American Association of Zoo Veterinarians Annual Conference, Omaha NE
1998 Association of Avian Veterinarians Annual Conference, Minneapolis MN
1997 Association of Reptilian and Amphibian Veterinarians Annual Conference Houston TX
1997 American Association of Zoo Veterinarians Annual Conference Houston TX
1997 ACZM Training Course, Raleigh NC
1996 American Association of Zoo Veterinarians Annual Conference, Puerto Vallarto MX

1995 American Association of Zoo Veterinarians Annual Conference, East Lansing MI
1995 ACZM Training Course, Raleigh NC
1995 WEZAM Exotics Conference, Madison WI
1995 Feline Respiratory Disease Seminar, Columbus OH
1995 OVMA Annual Conference, Columbus OH
1994 American Association of Zoo Veterinarians Annual Conference, Pittsburgh PA
1994 Food Animal Medicine Short Course, Columbus OH
1994 North American Veterinary Conference, Orlando FL
1993 Fish Health Management University of Georgia, Athens GA
1993 American Association of Zoo Veterinarians Annual Conference, St. Louis MO.
1992 Association of Avian Veterinarians Annual Conference, New Orleans LA
1992 American Association of Zoo Veterinarians Annual Conference, Oakland CA
1992 CBSG International Conference on Implications of Infectious Diseases for Captive Propagation and Reintroduction Programs of Threatened Species, Oakland CA

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Wildlife Biologist
U.S. Geological Survey
Alaska Science Center
Nearshore Marine Ecosystem Research
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Anchorage, AK 99508

Objective

###
Full Curriculum–Vitae 2019

Education

University of Alaska Fairbanks
September 2015 - Present
Ph.D. Candidate, Marine Biology
Advisors: Dr. Brenda Konar & Dr. Daniel Esler

University of California, Santa Cruz
September 2010 - March 2013
M.A. Ecology & Evolutionary Biology
Advisors: Dr. M. Tim Tinker & Dr. James A. Estes

University of California, Santa Cruz
September 2004 - June 2008
B.S. Marine Biology
Advisor: Dr. Terrie M. Williams

Employment

Wildlife Biologist – Pathways Student Trainee (GS-09/11)
US Geological Survey (Alaska Science Center), February 2013 - Present

- Manage and conduct scientific investigations of nearshore ecosystems as part of the Gulf Watch Alaska (co-PI) monitoring program and on-going collaborations with other federal and academic institutions.
- Liaison between USGS Alaska Science, USGS Western Ecological Research Center, University Alaska Fairbanks, and other institutions for coordination of collaborative intra- and inter-agency projects.
- Responsible for leading dynamic projects in the field, coordinating field logistics, and managing multiple concurrent projects.
- Contributions to reports and publications: writing, data analysis, and synthesis across inter-disciplinary projects.
- Participation in public speaking and outreach about natural history and nearshore ecology (see presentations).
- Development of proposals to other funding agencies.
- Specific skills include conducting sea otter captures using highly specialized CCR (Closed Circuit Rebreather) and SCUBA diving techniques, tracking of tagged sea otters using telemetry, maintenance of watercraft and sensitive dive equipment, surveys of benthic communities, marine bird and mammal surveys, sea otter aerial surveys using ISU methodology, sea otter feeding observations, habitat and invertebrate resource sampling using SCUBA, field logistics management, data

management, data analysis in contribution to summaries, reports, and publications.
- Supervisors: Dr. Daniel Esler (ASC).

Graduate Student Researcher/Biologist (GS-07, GS-09)
US Geological Survey (Western Ecological Resource Center & Alaska Science Center), April 2010- February 2013
- Duties included conducting sea otter captures using highly specialized CCR (Closed Circuit Rebreather) and SCUBA diving techniques, tracking of tagged sea otters using telemetry, census of the CA sea otter population, maintenance of watercraft and sensitive dive equipment, surveys of intertidal monitoring sites, marine bird and mammal surveys, sea otter aerial surveys using ISU methodology, sea otter observations using established techniques, habitat and invertebrate resource sampling using SCUBA, data management and analysis.
- Time was split between the Western Ecological Resource Center – Santa Cruz Field Station from September-April and the Alaska Science Center, Anchorage, from April-August each year.
- Gained experience in coordinating field logistics, leading dynamic projects in the field, synthesis of large data sets, Public speaking on natural history and nearshore ecology (see presentations), and coordination of collaborative intra- and inter-agency projects.
- Supervisors: Dr. Tim Tinker (WERC, retired), Jim Bodkin (ASC, retired), & George Esslinger (ASC).

Scientific Aide
California Dept. Fish & Wildlife, March 2008 – April 2010
- Primary duties as a field biologist conducting sea otter captures using highly specialized rebreather diving techniques, tracking of tagged sea otters using telemetry, census of the southern sea otter population, and recovery of dead sea otter carcasses. Fulfilled duties as a necropsy technician to assess pathology of wildlife, focused on sea otters, but also including marine birds, sea turtles, and terrestrial mammals. Trained in sterile technique and processing of water samples as part of a pollutant and pathogen transmission project.
- Supervisor: Jack Ames (retired) & Dr. Dave Jessup (retired)

Boat Yard/Facilities Assistant
UCSC, January 2007 - July 2008
- Providing support to UCSC's scientific diving program boat yard and facilities.
- Experience in construction, welding, fiberglass, boating and diving equipment maintenance, innovating techniques to achieve scientific goals, and heavy machinery operation.
- Supervisor: Pete dal Ferro (UCSC/USGS) & Nate Moore (UCSC)

Volunteer Experience

Marine Mammal Physiology Project, Animal Trainer
UCSC, October 2005 – May 2008
- Required to perform 20 hours of service per week in the husbandry and training of bottlenose dolphins, sea lions, seals, and sea otters for physiological studies to answer questions on metabolics and energetics.
- Experience in leadership, team building, animal handling, animal training, husbandry,

and data collection and management.
- Supervisor: Traci Kendall, Principal Investigator: Dr. Terrie Williams

PISCO Subtidal Technician
UCSC, Summer 2007: Partnership for the Interdisciplinary Studies of Coastal Oceans (PISCO)
- Conducted subtidal biodiversity surveys on temperate reef ecosystems across the central coast of California. Surveys included reef structure and biotic cover, macro-algae, and invertebrates. Long term ecological monitoring, recruitment and baseline monitoring for newly input Marine Protected Areas. Conducted fieldwork in all oceanic conditions, and from many types of watercraft. All surveys were conducted on SCUBA.
- Supervisor: Randolf Skrovan, Principal Investigator: Dr. Mark Carr

Teaching Experience
- UC Santa Cruz TA-ship: *Ecology*, led by Prof. James Estes

Mentoring Experience
- Undergraduate through the Alaska Native Science and Engineering Program (ANSEP) partnership with USGS: Yosty Storms
- Undergraduate Mentorship: Alaska Pacific University student thesis project, Kaitlyn Lawton, on sea urchin energetics.
- Guided and worked with multiple volunteers from USGS

Relevant Experience & Training

- **GIS:** Spatial data analysis, visualization, and collection in ESRI ArcDesktop10
- **R:** Data analysis, modeling, and visualization.
- **PRIMER-e + PERMANOVA:** Multivariate data analysis and visualization for biophysical synthesis.
- **Motorboat Operator Certification Course (MOCC)**: Dept. of Interior for small boat operations.
- **USGS Certified Deckhand:** Cook, crew, and science on a 50’ research vessel. Safety management, maintenance, routine operation, and overseeing science crews.
- **American Academy of Underwater Sciences (AAUS)** Current to 100’ depth
    - **UCSC Dive Safety Board Member**: 2007-2008
    - **Open Water Scuba Instruction:** PADI #191966, Over 100 students certified across basic, advanced, rescue, and divemaster ratings.
    - Drysuit, Nitrox, and Closed-circuit Rebreather certified.
- **CPR, First Aid, Oxygen administration:** Wilderness first aid for remote work in AK
- **Firearms and Defense Against Wildlife:** USGS
- **Software:**
    - Microsoft Office: Access, Excel, Powerpoint, and Word
    - Adobe: Dreamweaver, Illustrator, Photoshop
    - Data Acquisition: HOBOware, Castaway, DNRGPS, Image-J
    - Other Statistics: SYSTAT, SAS, JMP

Contributions to the Field

Benjamin Phillip Weitzman

Peer-Reviewed Publications & Reports

- Rasher, D., Steneck, R., Estes, J., Halfar, J., Kroeker, K., Ries, J., Chan, P., Fietzke, J., Konar, B., Norley, C., **Weitzman, B.,** and Westfield, I. (in review) Climate Change Amplifies Trophic Cascades in a Kelp Forest Ecosystem. *Science.*
- Tinker, M.T., Tomoleoni, J., **Weitzman, B.,** 12 others… (2019) Comparing a clean and dirty ocean: Sea otter health, ecology, and behaviour in Big Sur VS Monterey, CA. *USGS Open File Report.* Western Ecological Research Center, U.S. Geological Survey, Sacramento, CA.
- Garlich-Miller, J., Esslinger, G., and **Weitzman, B**. (2018) Aerial surveys of sea otters (*Enhydra lutris)* in lower cook inlet, Alaska, May, 2017. *USFWS Technical Report MMM 2018-01*. U.S. Fish & Wildlife Service, Marine Mammals Management. Anchorage, AK.
- Ebert, T., Barr, L., …, **Weitzman, B.,** 30 others… (2018) Size, growth, and density data for shallow-water sea urchins from Mexico to the Aleutian Islands, Alaska, 1956–2016. *Ecology*, *99*(3), 761-761.
- Coletti, H., Esler, D., Ballachey, B., Bodkin, J., Esslinger, G., Kloecker, K., Monson, D., Robinson, B., **Weitzman, B.**, Dean, T., and Lindeberg. M. (2018) Gulf Watch Alaska: Nearshore benthic systems in the Gulf of Alaska. Long-Term Monitoring Program (Gulf Watch Alaska) Final Report (*Exxon Valdez* Oil Spill Trustee Council Project 16120114-R), *Exxon Valdez* Oil Spill Trustee Council, Anchorage, Alaska.
- **Weitzman, B**., Bodkin, J., Kloecker, K., and Coletti, H. (2017) SOP for monitoring intertidal bivalves on mixed-sediment beaches — version 2.0: Southwest Alaska Inventory and Monitoring Network. Natural Resource Report NPS/SWAN/NRR—2017/1443. National Park Service, Fort Collins, Colorado.
- Konar, B., Edwards, M. S., Bland, A., Metzger, J., Ravelo, A., Traiger, S., & **Weitzman, B.** (2017). A swath across the great divide: kelp forests across the Samalga Pass biogeographic break. *Continental Shelf Research*.
- Konar, B., Iken, K., Coletti, H., Monson, D., & **Weitzman, B.** (2016). Influence of Static Habitat Attributes on Local and Regional Rocky Intertidal Community Structure. *Estuaries and Coasts*, pp 1-11.
- Ballachey, B., Bodkin, J., Coletti, H., Dean, T., Esler, D., Esslinger, G., Iken, K., Konar, B., Lindeberg, M., Monson, D., Shephard, M., and **Weitzman, B**. (2015) Variability within Nearshore Ecosystems of the Gulf of Alaska. Synthesis Report for Gulf Watch Alaska Long Term Monitoring Program, pp 1-7.
- Esslinger, G., Bodkin, J., & **Weitzman, B.,** (2015) Aerial Sea Otter Abundance Surveys – Prince William Sound, Alaska, Summer 2014. Administrative report for USFWS Region 7, pp 1-9.
- **Weitzman, B.,** Esslinger, G., Bodkin, J., (2013) Using a Diver-operated Suction Dredge to Evaluate the Effects of a Top-predator on Subtidal Soft-sediment Infaunal Bivalve Communities, in Stellar, D., Lobel, L., eds., Proceedings of the American Academy of Underwater Sciences 31st Symposium, September 24-29, 2012. Monterey, CA: Diving for Science 2012. pp 103-109
- Esslinger, G., Bodkin, J., **Weitzman, B.** (2013) Sea otter Population Abundance and Distribution in Glacier Bay, Alaska. Administrative Report for USFWS Region 7, pp 1-11.
- Coletti, H., Esslinger G., and **Weitzman, B.** (2013) Sea Otter Abundance in Katmai National Park and Preserve: Results from the 2012 Aerial Survey, Southwest Alaska Network Inventory and Monitoring Program. Natural Resource Technical Report. National Park Service, Fort Collins, Colorado.

Peer-reviewed Published Datasets

- Kloecker, K. A. and **Weitzman, B.P.** (2018) Gulf Watch Alaska Nearshore Component:

Intertidal Soft-Sediment Invertebrates from Prince William Sound, Katmai National Park and Preserve, and Kenai Fjords National Park, 2007-2015: U.S. Geological Survey data release

- Monson, D. H., Kloecker, K. A., Ballachey, B. E., Bodkin, J. L., Coletti, H. A., Dean, T. A., Esler, D., Esslinger, G. G., Paszalek, J. and **Weitzman, B.P.** (2016) Gulf Watch Alaska Benthic Component: Marine Water Quality, Water Temperature from Prince William Sound, Katmai National Park and Preserve, and Kenai Fjords National Park, 2006-2014: U.S. Geological Survey data release
- Kloecker, K. A., Ballachey, B. E., Bodkin, J. L., Coletti, H. A., Dean, T. A., Esler, D., Esslinger, G. G., Lindeberg, M. R., Monson, D. H., Paszalek, J. and **Weitzman, B.P.** (2016) Gulf Watch Alaska Nearshore Component: Intertidal Mussel Site Data from Prince William Sound, Katmai National Park and Preserve, and Kenai Fjords National Park, 2008-2015: U.S. Geological Survey data release

Service

Professional Meetings:

- Western Society of Naturalists Meeting, November 12th, 2010: Talk, "The Effects of Sea Otter Recolonization on Benthic Intertidal Invertebrate Communities in Glacier Bay National Park & Preserve, Alaska"
- Sea Otter Conservation Workshop, Seattle, March 26th, 2011: Talk, "Sea Otter Impacts on Soft-Sediment Intertidal Communities in Glacier Bay National Park & Preserve, Alaska"
- Southern Sea Otter Research Update Meetings, Santa Cruz, February 9th, 2012: Talk, "The effects of sea otters on soft-sediment communities in Glacier Bay, Alaska"
- Southern Sea Otter Research Update Meetings, Santa Cruz, February 9th, 2012: Talk, "Exxon Valdez Oil Spill Long Term Monitoring of the Nearshore Environment"
- American Academy of Underwater Sciences, September 29th, 2012: *Talk*, "Using a diver-operated suction dredge to evaluate the effects of a top-predator on subtidal soft-sediment infaunal bivalve communities"
- American Academy of Underwater Sciences, September 29th, 2012: *Talk Co-Author*, "Closed-Circuit Diving Techniques for Wild Sea Otter Capture"
- Alaska Marine Science Symposium, January 24th, 2013: *Talk*, "Colonization in Action: Understanding the impacts of sea otters on soft-sediment invertebrate communities"
- Sea Otter Conservation Workshop. Seattle, WA, February, 2013: *Remote Talk*, "Colonization in Action: Understanding the impacts of sea otters on soft-sediment invertebrate communities"
- Southern Sea Otter Research Update Meetings, February 25th, 2014: *Talk*, "Variation in Body Condition in Sea Otter Populations"
- Alaska Marine Science Symposium, January 20th, 2015: *Poster Co-Author*, "Communities associated with crustose coralline algae reef habitat in the western Aleutian Islands"
- Alaska Marine Science Symposium, January 20th, 2015: *Poster Co-Author*, "Inter-annual and spatial variation in Pacific blue mussels (*Mytilus trossulus*) in the Gulf of Alaska, 2006-2013"
- Alaska Marine Science Symposium, January 20th, 2015: *Poster*, "Implications of recolonization and food limitation for sea otters in soft-bottom habitats of Glacier Bay, AK"

- Sea Otter Conservation Workshop. Seattle, WA, March, 27th 2015: *Talk*, "After two decades in Glacier Bay: Implications of Recolonization and Resource Dynamics for Sea Otters in Soft-Bottom Habitats of the North Pacific"
- Alaska Marine Science Symposium, January 21st, 2016: *Poster*, "Variability in sea urchin population size structure at multiple spatial scales across the Aleutian Islands: implications for sea otters"
- Alaska Marine Science Symposium, January 21st, 2016: *Poster Co-Author*, "Updates of key metrics from long-term monitoring of nearshore marine ecosystems in the Gulf of Alaska: Detecting change and understanding cause"
- Alaska Marine Science Symposium, January 21st, 2016: *Poster Co-Author*, "Multi-agency Efforts to monitor Sea Star Wasting Disease in Alaska: Results and Recommendations for Future Efforts"
- NPS Centennial Science Symposium, Fairbanks, October 2016, *Poster Co-Author* "Updates of key metrics from long-term monitoring of nearshore marine ecosystems in the Gulf of Alaska: Detecting change and understanding cause."
- NPS Centennial Science Symposium, Fairbanks, October 2016, *Talk*, "Happy as a clam? Variation in bivalve abundance throughout the northeastern Pacific."
- Western Society of Naturalists Meeting, November 10-13th, 2016: *Talk,* "Variability in green sea urchin demography at multiple spatial scales across the Aleutian Archipelago"
- Western Society of Naturalists Meeting, November 10-13th, 2016: *Poster Co-Author,* "Communities associated with a massive crustose coralline algae reef habitat in the western Aleutian Islands"
- Alaska Bird Conference, Cordova, December 2016. *Talk Co-Author*, "Barrow's Goldeneye Demographic Responses to Changing Mussel Conditions on Wintering Areas: A Conceptual Model Exercise."
- Alaska Marine Science Symposium, January 24th, 2017: *Poster Co-Author*, "Spatial variability in mussel size frequency distribution in the Gulf of Alaska."
- Alaska Marine Science Symposium, January 24th, 2017: *Poster Co-Author*, "Trends in intertidal seastar abundance and diversity across the Gulf of Alaska: looking for effects of seastar wasting."
- Alaska Marine Science Symposium, January 24th, 2017: *Poster Co-Author*, "Nearshore Marine Consumer Responses to Changing Prey Conditions: Combining Quantitative and Qualitative Model Input into a Conceptual Framework."
- Alaska Marine Science Symposium, January 24th, 2017: *Talk,* "Can you dig it? Patterns of variability in clam assemblages within mixed-sediment habitats across the Gulf of Alaska"
- Sea Otter Conservation Workshop Seattle, WA, March 17-19 2017: *Talk Co-Author,* "Understanding Trophic Relationships of Sea Otters and Their Effects on Demographic Attributes."
- Sea Otter Conservation Workshop Seattle, WA, March 17-19 2017: *Talk Co-Author*, "A century of sea otter science and conservation in National Parks"

- Western Society of Naturalists Meeting, November 16-19th, 2017: *Talk Co-Author,* "Mechanisms Leading To The Increase Of The Coarse Spongy Cushion Codium ritteri Within Urchin Barrens"
- Alaska Marine Science Symposium, January 21-25, 2018: *Poster Co-Author*, "Congruence of intertidal and pelagic water and air temperatures during an anomalously warm period in the northern Gulf of Alaska; the "Blob" washes ashore."
- Alaska Marine Science Symposium, January 21-25, 2018: *Poster Co-Author*, "Trends in intertidal sea star abundance and diversity across the Gulf of Alaska: effects of sea star wasting."
- Alaska Marine Science Symposium, January 21-25, 2018: *Poster Co-Author*, "A decade's worth of data: Key metrics from a large-scale, trophic web based long term monitoring program in the northern Gulf of Alaska."
- Alaska Marine Science Symposium, January 21-25, 2018: *Poster Co-Author*, "Mechanisms Leading To The Increase Of The Coarse Spongy Cushion Codium ritteri Within Urchin Barrens"
- Alaska Marine Science Symposium, January 21-25, 2018: *Talk Co-Author,* "Detecting and inferring cause of change in Alaska nearshore marine ecosystem: An approach using sea otters as a component of the nearshore benthic food web"
- Alaska Marine Science Symposium, January, 2018: *Talk*, "Sea urchin demography and ecosystem consequences across the Aleutian Archipelago: A story from the top-down, bottom-up, and side-to-side."

Professional Reviews

- Marine Environmental Research: 2016 (1)
- Journal of Experimental Marine Biology and Ecology: 2017 (2), 2018 (1), 2019 (1)
- Marine Ecological Progress Series: 2018 (1)

Institutional Speaking:

- UCSC/Stanford Species Interactions Workshop, December 3rd, 2011: Talk, "Mucking it Up: The effects of sea otters on soft-sediment intertidal clam communities"
- UCSC Graduate Research Science Symposium, March 3rd, 2012: Talk, "The effects of sea otters on soft-sediment invertebrate communities in Glacier Bay, Alaska"
- USGS Alaska Science Center Seminar Speaker, August, 21, 2012: *Seminar*, "The Effects Of Sea Otters On Soft-Sediment Invertebrate Communities In Glacier Bay Nat'l Park"
- UC Santa Cruz Thesis Defense Seminar, January 18th, 2013: *Seminar*, "The Effects of Sea Otter Colonization on Soft-Sediment Intertidal Prey Assemblages in Glacier Bay, Alaska"
- UAF College of Fisheries & Ocean Sciences Spring Seminar Series, April 5th, 2017: *Talk*, "Biodiversity in the Aleutian Archipelago: trends and causes"
- UAF College of Fisheries & Ocean Sciences Special Seminar, April 19th, 2018. *Talk,* "Assessing drivers of variability in macroinvertebrate abundance and productivity across the northeast Pacific"
- Glacier Bay National Park Service, Ranger Training Series, April 26th, 2018: *Talk*, "Sea otter biology and ecology across the north Pacific"

- UAF College of Fisheries & Ocean Sciences Special Seminar, February 27th, 2019. *Talk*, "Can you dig it? Patterns of variability in clam assemblages across the Gulf of Alaska"

Institutional Reviews:

- USGS Internal reviewer: 2017 (2), 2018 (1)

Public Speaking & Outreach Events:

- Seymour Marine Discovery Center's Science Sunday Series, February 20th, 2011: Public Seminar, "More Than Just a Furry Face: The natural history of sea otters along the Pacific Coast". Santa Cruz, CA
- Sea Otter Awareness Week Lecture Series, September 29th, 2011: Seminar, "The Effects of Sea Otters on Soft-Bottomed Ecosystems". Santa Cruz, CA
- ANSEP School visit, Fall 2015. Alaska Native Science and Engineering program event. Anchorage, AK
- National Park Service video series, Summer 2016. Gulf Watch Alaska nearshore program video. Seward, AK
- Frontiers in Science, Spring 2016. Documentary interview on sea otter research using UAS. Fairbanks, AK
- Gulfwatch PI meeting outreach event, November 2016: Public display on nearshore ecology. Cordova, AK
- Delta Sound Connections article: Unhappy as a clam? 2017-2018. Prince William Sound Science Center.
- Radio interview: Can sea stars make a comeback in Kachemak Bay? August 14. 2017. KBBI Radio, Homer, AK
- UAF Science Potpourri, April 2017: Public outreach event. Fairbanks, AK
- Port Graham Native Corporation listening session, May 18th, 2018: Public discussion with elders. Port Graham, AK

[redacted]

References

[redacted]

Benjamin Phillip Weitzman

[redacted]

Julie L. Yee

U.S. Geological Survey, Western Ecological Research Center
Santa Cruz Field Station, 2885 Mission St., Santa Cruz, CA 95060
Dixon Field Station, 800 Business Park Drive, Suite D, Dixon, CA 95620
Tel. 530-669-5097, Fax 707-678-5039, julie_yee@usgs.gov

Education

Ph.D., Statistics
University of California, Davis, 1997

M.S., Statistics
University of California, Davis, 1993

B.S., Mathematics
California Institute of Technology, 1991

Dissertation Title: Asymptotic Approximations to Bayesian Posterior Distributions in Survival Problems with Incomplete Data.
Emphasis: biostatistics, survival analysis, linear model theory, simulation and resampling methods of data analysis, spatial statistics, nonparametric inference.

Employment

Biology Statistician
United States Geological Survey, Western Ecological Research Center (WERC)
Aug 1997 – present

- Research and statistical computing collaboration to principal research scientists. Became principal investigator of WERC sea otter program in 2018.

Associate Instructor
UC Davis, Division of Statistics
Jan 1997 – Jun 1997

- "Statistical Analysis Through Computers," including the theory and application of probability, statistics, and computer simulation.

Recent Products

Stephenson, NL, AJ Das, NJ Ampersee, BM Bulaon, and JL Yee. In press. Which trees die during drought? The key role of insect host-tree selection. Journal of Ecology (doi: 10.1111/1365-2745.13176)

Zimmerman, GS, VW Varela, and JL Yee, 2019, Detection probabilities of bird carcasses along sandy beaches and marsh edges in the northern Gulf of Mexico. Environmental Monitoring and Assessment. In press.

Capitolo, PJ, HR Carter, JL Yee, GJ McChesney, MW Parker, RJ Young, RT Golightly, and WB Tyler, 2019, Changes in breeding population sizes of double-crested cormorants *Phalacrocorax Auritus* in the Humboldt Bay area, California, 1924-2017. Marine Ornithology. In press.

Hatfield, BB, JL Yee, MC Kenner, JA Tomoleoni, and MT Tinker, 2018, California sea otter (Enhydra lutris nereis) census results, spring 2018: U.S. Geological Survey Data Series 1097, 10 p., https://doi.org/10.3133/ds1097.

Fleskes, JP, AM Ramey, AB Reeves, JL Yee. 2017. Body mass, wing length, and condition of wintering ducks relative to hematozoa infection. Journal of Fish and Wildlife Management. doi: http://dx.doi.org/10.3996/082016-JFWM-063

Takekawa, JY, WM Perry, J Adams, Josh, JJ Felis, LL Williams, JL Yee, DL Orthmeyer, JW Mason, GJ McChesney, WR McIver, HR Carter, and RT Golightly, 2017. At-sea distribution and abundance of seabirds and marine mammals off southern California GIS resource database: Aerial seabird and marine mammal surveys off southern California, 1999–2002: U.S. Geological Survey data release, https://doi.org/10.5066/F7PK0D9P

Alpers, CN, JL Yee, JT Ackerman, JL Orlando, DG Slotton, and MC Marvin-DiPasquale, 2016, Prediction of fish and sediment mercury in streams using landscape variables and historical mining: Science of the Total Environment, v. 571 (15 November 2016), p. 364-379, DOI: 10.1016/j.scitotenv.2016.05.088. [First online 2 July 2016]

Fleskes, JP, JL Yee, GS Yarris, DL Loughman. 2016. Increased body mass of ducks wintering in California's Central Valley. Journal of Wildlife Management. doi: 10.1002/jwmg.1053

Ackerman, JT, CA Eagles-Smith, MP Herzog, JL Yee, CA Hartman. 2015. Egg laying sequence influences egg mercury concentrations and egg size in three bird species: Implications for contaminant monitoring programs. Environmental Toxicology and Chemistry. In press. doi: 10.1002/etc.3291

Berry, KH, AA Coble, JL Yee, JS Mack, WM Perry, KM Anderson, MB Brown. 2015. Distance to human populations influences epidemiology of respiratory disease in desert tortoises. The Journal of Wildlife Management 79(1):122–136. doi: 10.1002/jwmg.816

Meese, RJ, JL Yee, M Holyoak. 2015. Sampling to Estimate Population Size and Detect Trends in Tricolored Blackbirds. CVBC Bulletin 17(2-4):51-56.

Miles, AK, DH Van Vuren, DC Tsao, JL Yee. 2015. Experimental enhancement of pickleweed, Suisun Bay, California. California Fish and Game 101(2): 87-100.

Ackerman, JT, CA Hartman, MP Herzog, LM Smith, SM Moskal, SEW De La Cruz, JL Yee, and JY Takekawa, 2014, The critical role of islands for waterbird breeding and foraging habitat in managed ponds of the South Bay Salt Pond Restoration Project, South San Francisco Bay, California: U.S. Geological Survey Open-File Report 2014-1263, 108 p., http://dx.doi.org/10.3133/ofr20141263.

Berry, KH, LM Lyren, JL Yee, TY Bailey. 2014. Protection benefits desert tortoise (Gopherus agassizii) abundance: the influence of three management strategies on a threatened species. Herpetological Monographs 28(1): 66-92. doi: 10.1655/HERPMONOGRAPHS-D-14-00002

O'Neil, ST, JM Warren, JY Takekawa, SEW De La Cruz, KA Cutting, MW Parker, and JL Yee. 2014. Behavioural cues surpass habitat factors in explaining prebreeding resource selection by a migratory diving duck. Animal Behaviour 90: 21-29. doi: 10.1016/j.anbehav.2014.01.004

De La Cruz, SEW, JM Eadie, AK Miles, J Yee, KA Spragens, EC Palm, JY Takekawa. 2014. Resource selection and space use by sea ducks during the non-breeding season: Implications for habitat conservation planning in urbanized estuaries. Biological Conservation 169: 68-78. doi: 10.1016/j.biocon.2013.10.021

Curriculum Vitae
COLLEEN YOUNG
California Department of Fish and Wildlife, Office of Spill Prevention and Response
Marine Wildlife Veterinary Care and Research Center
151 McAllister Way, Santa Cruz, CA 95060
831.212.7010 (cell); 831.469.1740 (office); 831.469.1723 (fax)
colleen.young@wildlife.ca.gov

EDUCATION

Master of Science, Marine Science, Moss Landing Marine Laboratories, San José State University, December 2009
Bachelor of Science, Animal Biology, University of California, Davis, June 2006

RELEVANT EMPLOYMENT HISTORY

2011-present Environmental Scientist/Sea Otter Biologist, CA Dept of Fish and Wildlife, Office of Spill Prevention and Response, Santa Cruz, CA
2010-2011 Staff Research Associate II, UC Davis Wildlife Health Center/Marine Wildlife Veterinary Care and Research Center, Santa Cruz, CA
2010-2011 Scientific Aid, California Department of Fish and Game/Marine Wildlife Veterinary Care and Research Center, Santa Cruz, CA
2009-2011 Marine Mammal Observer, MLML/NOAA, central CA
2009-2010 Research Associate, Central CA Seabird Health Study, Moss Landing Marine Laboratories/Marine Wildlife Veterinary Care and Research Center, Santa Cruz, CA
2009-2010 Graduate Student Assistant, Teacher Enhancement Program, Moss Landing Marine Laboratories, Moss Landing, CA
2009-2010 Coordinator, Monterey County Marine Mammal Stranding Response Network, Moss Landing Marine Laboratories, Moss Landing, CA
2007-2009 Primary Investigator, Harbor Seal Disturbance Study, National Park Service, Glacier Bay, AK
2006-2007 Private Science Tutor, Sylvan Learning Center, Pacific Grove, CA
2005-2006 Peer Science Tutor, UC Davis, Davis, CA
2003-2004 Veterinary Student Technician, UC Davis Veterinary Medicine Teaching Hospital, Davis, CA

RESEARCH AND FIELD EXPERIENCE

Marine mammal, seabird and sea turtle capture, tagging, and biological sampling

- Sea otters: central CA (June 2010-present)
    - Wilson traps/rebreather diving, tangle nets, dip nets – flipper tags, TDRs, VHF transmitters, biological sampling
- Harbor seals: San Francisco Bay, CA (2007-2010), Glacier Bay, AK (2007)
    - Tangle nets, dip nets – flipper tags, satellite tags, VHF transmitters, biological sampling

- Common Murres: Monterey Bay, CA (2013)
    - Spotlighting – captured for dispersant study
- Marbled Murrelets: Ano Nuevo Bay, CA (2010)
    - Spotlighting – banding, biological sampling
- Rhinoceros Auklets: Ano Nuevo Island, CA (2011, 2012)
    - Mist netting – banding, biological sampling
- Green sea turtles: Baja California, MX (March 2007)
    - Tangle nets – flipper tags
- Leatherback sea turtles: central California (October 2007 & 2008)
    - Hoop net - suction cup tags, biological sampling

Stranded marine mammal response/carcass recovery
- Dead marine mammals
    - Sea otters: central CA (2010-present)
    - Cetaceans, pinnipeds: Monterey County, CA (2006-2010)
- Live marine mammals
    - Sea otters: central CA (2012-present)
    - Pinnipeds: Monterey County, CA (sporadically 2006-2010)

Marine vertebrate and elasmobranch necropsy
- Sea otters (2009-present)
- Cetaceans & pinnipeds (2007-2011)
- Seabirds (2007-2011)
- Sea turtles (sporadically and opportunistically 2007-present)
- White sharks (sporadically and opportunistically 2017-present)

Marine mammal and sea bird population/abundance monitoring
- Aerial
    - Sea otter census surveys, central CA (2010-present)
    - Marine mammal and leatherback turtle surveys, central CA (2009-2011)
- Land-based
    - Sea otter census surveys, central CA (2010-present)
    - Harbor seal monitoring study, Glacier Bay, AK (2007-2008)
- Vessel-based
    - Marine mammal, seabird, and leatherback turtle surveys, central CA (2008-2013)

Telemetry
- VHF radio tracking
    - Sea otters, central CA (2010-present)
    - Harbor seals, Glacier Bay, AK (2007)
    - Green sea turtles, Baja California, MX (2007)

Scientific diving and boating
- 100% O_2 Rebreather diving: sea otter captures (2010-present)

- Scientific diver
  - California Department of Fish and Wildlife (2010-present)
  - Monterey Bay Aquarium (2009-present)
  - Moss Landing Marine Labs (2006-2010)
  - UC Davis (2005-2006)
- Boating
  - CDFW boat handler (2010-present)
  - Deckhand/Divemaster on recreational dive boats, central CA (2006-2010)

Marine vertebrate behavioral observations

- Research participant: ongoing sea otter behavioral studies, central CA (2010-present)
- Principal investigator: harbor seal study (behavioral observations, energetic modeling) – Master's thesis, Glacier Bay, AK (2007-2009)
- Intern: juvenile dolphin behavior study (behavioral observations, boat driving, data entry) – Mote Marine Laboratory, Sarasota, FL (2005)

Thermography

- Research associate: seabird thermography study – using thermal imagery to assess thermal stability and waterproofing in captive and rehabilitated seabirds, central CA (2010-2011)

Other research experience and relevant skills

- Field technician/diver – Caribbean Wrasse specimen collection and gamete dissection, Florida Keys, FL (2005)
- Underwater acoustic receiver array deployment and retrieval – various MLML student thesis projects, central CA (2007-2009)
- Specimen collection of intertidal and subtidal kelp and invertebrates – various MLML student thesis projects, central CA (2007-2009)
- Theodolite operator – used to obtain bearings on vessels and seals in Glacier Bay, AK (2007-2008)
- Extensive data and database management experience, MS Excel and MS Access (2007-2011)
- ATV operator (2012-present)
- Beach driving (2011-present)

OIL SPILL PREPAREDNESS AND RESPONSE

Oil spill preparedness training

- 24-hr HAZWOPER (Nov 2010); last annual 8-hr refresher (Dec 2018)
- FEMA ICS-100, 200
- PRBO Wildlife Processing
- Environmental Response to Oil Spills training (2012)

- Annual table top and full deployment spill drills and annual floating sea otter pen deployment drills (2010-present)

Oil spill/algae event response experience

- Santa Cruz Mystery Spill – dead bird inventory (2007)
- Oregon Harmful Algal Bloom – live bird handling (2009)
- Refugio Oil Spill, Santa Barbara County, CA – wildlife reconnaissance, recovery, and transport (May 2015)

LIVE ANIMAL HANDLING AND REHABILITATION EXPERIENCE

• Seabird restraint, various species (alcids, grebes, loons, pelicans, etc.) – rehabilitation setting - International Bird Rescue, Cordelia, CA and Monterey SPCA Wildlife Center (sporadically 2009-present)
• Seabird restraint, various species (alcids, grebes, loons, pelicans, etc.) – field research and field recovery settings – central CA (2010-present)
• Sea otter restraint – field research setting – central CA (2010-present)
• Harbor seal restraint – field research setting – central CA (2007-2011)
• Domestic companion animal restraint – clinical setting – UC Davis VMTH, Davis, CA (2003-2004)

PUBLICATIONS

Young, C, Eguchi, T, Ames, JA, Staedler, M, Hatfield, BB, Harris, M, and Golson-Fisch, EA. 2018. Drift and beaching patterns of sea otter carcasses and car tire dummies. Marine Mammal Science, *in press*.

Young, C, Miller, MA, Kuchta, R, Brabec, J, Newsome, S, and Dailey, M. 2017. First report of an adult tapeworm (Cestoda: Diphyllobothriidea) in a southern sea otter (*Enhydra lutris nereis*). Journal of Wildlife Diseases, 53(4): 934-937.

Law, CJ, **Young, C**, and Mehta, RS. 2016. Ontogenetic scaling of theoretical bite force in southern sea otters (*Enhydra lutris nereis*). Physiological and Biochemical Zoology 89(5): 347-363.

Lieske, D, Vapniarsky, N, Verstraete, FJM, Leale, DM, **Young, C**, and Arzi, B. 2015. Characterization of the temporomandibular joint of southern sea otters (*Enhydra lutris nereis*). Frontiers in Veterinary Science. 2:71

Young, C, Gende, SM, and Harvey, JT. 2014. Effects of vessels on harbor seals in Glacier Bay National Park. Tourism in Marine Environment, 10(1-2): 5-20.

Hughes, SN, Tozzi, S, Harris, L, Harmsen, S, **Young, C**, Rask, J, Toy-Choutka, S, Clark, K, Cruickshank, M, Fennie, H, Kuo, J, and Trent JD. 2014. Interactions of marine mammals and birds with offshore membrane enclosures for growing algae (OMEGA). Aquatic Biosystems, 10:3

Harris, L, Tozzi, S, Wiley, P, **Young, C**, Richardson, TMJ, Clark, K, and Trent, JD. 2013. Potential impact of biofouling on the photobioreactors of the Offshore Membrane Enclosures for Growing Algae (OMEGA) system. Bioresource Technology, 144: 420-428.

Young, C, Gende, SM, and Harvey, JT. 2010. Disturbance of harbor seals by vessels in Johns Hopkins Inlet. Alaska Park Science, 9(2): 57-59.

Young, C. 2009. Disturbance of harbor seals by vessels in Johns Hopkins Inlet, Glacier Bay, AK. Master's Thesis, San Jose State University/Moss Landing Marine Laboratories, 112 p.

DISTINCTIONS/HONORS

• CDFW Employee Excellence Award for "Partnership" (2018)
• CDFW Employee Excellence Award for "Vision" (2014)
• Dean's Honors List, College of Agricultural & Environmental Sciences (UC Davis: fall 2002-spring 2005, spring 2006)
• Student leadership award (UC Davis, 2002-2003)

VOLUNTEER WORK/PUBLIC OUTREACH

• Volunteer diver, Monterey Bay Aquarium (2009-present)
• BeachCOMBERS volunteer (2006-present)
• Marine Mammal Stranding Network volunteer, Moss Landing Marine Laboratories (2006-2009)
• Moss Landing Marine Laboratories Annual Open House Volunteer (2006-2009)

ADDITIONAL CERTIFICATIONS/TRAINING

• NAUI Basic SCUBA Diver – 06/2004
• NAUI Advanced SCUBA Diver – 06/2005
• NAUI Divemaster – 06/2006
• AAUS Research diver – 06/2005
• NAUI Enriched air/Nitrox diver – 06/2005
• NAUI Drysuit diver – 06/2007
• DAN First Aid, CPR, O_2 Administration, and AED – renewed 10/2018
• DAN Emergency Management Provider – renewed 10/2018
  - o Advanced O2 First Aid for SCUBA Diving Injuries
  - o Neurological Assessment for Divers
• Water survival/helicopter underwater egress training – renewed 01/2017
• Wire strike avoidance – 08/2016
• Wilderness First Aid – 09/2016
• Swiftwater rescue – 06/2018
• Motorboat Operator Training Course - June 2017
• Department of Boating and Waterways, California Boating Safety – renewed 06/2018
• Small boats operator, MLML - 2008
• ATV operator training – 04/2012

U.S. GEOLOGICAL SURVEY WESTERN ECOLOGICAL RESEARCH CENTER (WERC) ANIMAL CARE AND USE COMMITTEE (ACUC) APPROVAL FORM

PROJECT TITLE: Population Dynamics and Biology of Sea Otters

PRINCIPAL INVESTIGATOR: Julie Yee

DATE OF ACUC APPLICATION SUBMISSION: 11/20/18

VETERINARY REVIEWER: Dr. Bill Van Bonn

DATE OF VETERINARIAN REVIEW: 12/18/18

AS THE VETERINARY REVIEWER, I HEREBY CERTIFY THAT WITH MY KNOWLEDGE AND EXPERTISE, I HAVE REVIEWED THE DOCUMENT HEREIN FOR APPROPRIATENESS OF THE SPECIES AND THE NUMBER OF ANIMALS PROPOSED; THE DRUGS AND DOSAGES USED; METHODS OF ANIMAL RESTRAINT, CAPTIVITY, AND TRANSPORTATION (IF APPLICABLE); DIET SUPPLEMENTATION; ANY SURGICAL AND NON-SURGICAL PROCEDURES OR EXPERIMENTS PERFORMED ON THE ANIMALS INCLUDING EQUIPMENT USED; MONITORING AND MANAGEMENT OF DISCOMFORT, DISTRESS, OR PAIN TO ANIMALS; EUTHANASIA METHODS; AND ANY EXEMPTIONS FROM STANDARDS OF CARE, IF REQUESTED THAT NECESSARILY CAUSE PAIN OR DISTRESS TO THE ANIMAL(S) UNDER STUDY WITHOUT THE USE OF ANESTHETICS, ANALGESICS, OR TRANQUILIZING DRUGS, AND THAT ALL OF MY REVIEW COMMENTS HAVE BEEN SATISFACTORILY ADDRESSED.

VETERINARY SIGNATURE: [signature] DATE: 1 FEB 19

WERC ACUC CHAIR: Sarah Spring

AS THE ANIMAL CARE AND USE COMMITTEE CHAIR, I HEREBY CERTIFY THAT THE ANIMAL CARE AND USE APPLICATION HAS BEEN REVIEWED BY THE WESTERN ECOLOGICAL RESEARCH CENTER ANIMAL CARE AND USE COMMITTEE FOR COMPLETION AND THAT LESS STRINGENT COMMENTS WERE ADDRESSED PRIOR TO FORWARDING THE APPLICATION TO THE VETERINARIAN FOR REVIEW. FOLLOWING VETERINARIAN REVIEW THE ANIMAL CARE AND USE APPLICATION HEREIN HAS BEEN APPROVED BY THE WESTERN ECOLOGICAL RESEARCH CENTER ANIMAL CARE AND USE COMMITTEE.

ACUC CHAIR
APPROVAL SIGNATURE: ____________________ DATE: 2/6/2019

THIS ACUC IS VALID FOR THE DURATION OF THE PROJECT OR 5 YEARS AFTER DATE OF FINAL APPROVAL, WHICHEVER COMES FIRST.

THIS ACUC IS SET TO EXPIRE ON 2/6/24

-- WERC ACUC PROTOCOL -- Instructions

1. Answer every question in **blue ink**. Do not leave any answer spaces blank. If a question is not applicable, answer the question by explaining briefly why the question is not applicable. Upon completion, email the final copy and all of the requested supporting documentation to WERC Animal Care and Use Committee (ACUC) Chair, Sarah Spring (sarah_spring@usgs.gov) and send a carbon copy (Cc) to Shamara Gough (sgough@usgs.gov), WERC ACUC Committee Member.

NOTE: To mark any boxes, double click and select "checked" as default value.

2. If you rely on the scientific literature or on any of the following reference standards to explain or justify an answer, identify the reference:

- ILAR Guide to the Care and Use of Laboratory Animals
- American Society of Mammalogists Animal Care and Use Guidelines
- Ornithological Council Guidelines to the Use of Wild Birds in Research
- American Fisheries Society, American Institute of Fishery Research Biologists, and American Society of Ichthyologists and Herpetologists Guidelines to the Use of Fishes in Research
- American Society of Ichthyologists and Herpetologists Guidelines to the Use of Amphibians and Reptiles in Research

3. If you are working with collaborators and the protocol has already been reviewed by an ACUC at another institution, provide a copy of that protocol and the response by the ACUC, including questions or comments, and your answers to Sarah Spring (sarah_spring@usgs.gov) and Shamara Gough (sgough@usgs.gov) for review **prior** to completing this form.

4. Audiovisual material (e.g., sound files, photographs, maps, and/or video footage) of your field work may help the ACUC to understand your proposed research methods and techniques, but it is not required. If you have created an audiovisual record, please consider submitting it to the ACUC. If you submit such material, include descriptive captions for all photographs; i.e. what action is taking place, how, and why.

Audiovisual material is submitted in accompaniment to this form:

☐ YES

☒ NO

NOTE: It is unlawful to begin work until all federal or state permits required for your research have been issued. An ACUC may choose to request that you provide copies of your permits for the administrative record.

Two different laws – the Animal Welfare Act (AWA) and the Health Research Extension Act of 1985 are applicable to wildlife research. The Interagency Research Animal Committee (IRAC) published *U.S. Government Principles for the Utilization and Care of Vertebrate Animals Used in Testing, Research, and Training* extending AWA coverage to all vertebrates when work is conducted by Federal Researchers. This document also requires that, "the transportation, care, and use of animals should be in accordance with the Animal Welfare Act **and other** applicable Federal laws, guidelines, and policies." Therefore, guidelines from the Health Research Extension Act of 1985, as well as Public Health Service (PHS) Policy implemented by the National Institutes of Health (NIH) Office of Laboratory Animal Welfare (OLAW), are extended to all research involving live vertebrate animals. The ACUC will reference all of the above mentioned guidelines (and others) for review of this submitted protocol.

PRELIMINARY QUESTIONS

1. Does your research entail the study of live vertebrates?

☒ YES

☐ NO

Note: A study that entails the eggs and embryos of vertebrates are not covered until those eggs hatch. However, the larval forms of fish and amphibians are covered.

If the answer to Question 1 is NO, STOP here. Your research does not require ACUC approval. Please proceed to Section X-B.

If the answer to Question 1 is YES, proceed to answer Question 2.

2. If your research is to be conducted in the field, does the research involve invasive procedures, or will it harm or materially alter the behavior of an animal under study?

☒ YES

☐ NO

*Note: Any study that includes capture, handling, and marking of live vertebrates is subject to initial review. The ACUC will determine whether or not the project is a **field study** defined as a study conducted on free living wild animals in their natural habitat that does not involve invasive procedure or materially alter the behavior of the animal/species under study. If so, field studies are exempt from ACUC approval. The term "invasive procedure" is not defined by the Animal Welfare Act nor PHS policy. However, the Animal Welfare Act defines a "major operative procedure" as any surgical intervention that **penetrates and exposes a body cavity** or any procedure which produces permanent impairment of physical or physiological functions. For the purposes of completing this form, use the phrase "penetrates and exposes a body cavity," to mean invasive. OLAW defines "minor survival surgery" as one that <u>does not</u> expose a body cavity and causes little or no physical impairment. It is up to ACUC to determine if any operative procedure is minor and if it is invasive.*

If the answer to Question 2 is YES, then skip a-c and complete the rest of this form.

If the answer to Question 2 is NO, answer a-c, read the additional information, and proceed to Section X-C.

a) provide your name, phone number, and e-mail address.

Name: Click or tap here to enter text.

Phone: Click or tap here to enter text.

Email: Click or tap here to enter text.

b) briefly describe the nature of the research procedures and what measures you will take to assure that these procedures will not alter or influence the activity of the animals. For instance, if you plan to take photos, will you use a blind or other camouflage? Will you use a long lens so as to increase your distance from the animal?

Click or tap here to enter text.

c) describe where the studies will be located, what procedures will be involved, and the nature of the habitat where you will be working.

Click or tap here to enter text.

The ACUC will determine if further review is needed. If so, you will be asked to supply the additional information requested on this form. If not, you will receive email confirmation from the ACUC stating that your study qualifies as a 'field study,' is exempt from further ACUC review, and you may proceed with your research, subject to these two provisions:

1. You must notify us if a significant change to the project occurs. With regard to the "field study exemption," a change will be considered significant if the changes include an invasive procedure, or that harm the animal or materially alters the behavior of an animal under study or that alter or influence the behavior or the animal.

2. It is unlawful to begin work until all federal or state permits required for your research have been issued. An ACUC may choose to request copies of your permits for the administrative record.

Project title: Population Dynamics and Biology of Sea Otters

Umbrella study plan title (if applicable): Population Biology of Sea Otters in the Northeast Pacific

Approximate start date: 15 Dec 2018

Planned completion date: 15 Dec 2023

Principal investigator: Julie Yee

Permanent phone number: 916-284-7713

Field site phone number (if available):

E-mail address: Julie_yee@usgs.gov

If the PI will not be on site during the entire project, identify the individual or individuals who will be responsible for supervising the on-site work. Give the name, a contact phone number and e-mail address where that individual can be reached when the research is actively underway. This person must be able to assume responsibility for decisions and/or actions necessary to ensure animal health and welfare and the health and safety of all field workers. If this alternate cannot be contacted, the ACUC will assume responsibility and take actions deemed necessary to ensure appropriate animal care.

Alternate Supervisor Contact Information

Name and Title	Field Site Phone Number	E-mail Address
Joe Tomoleoni - Wildlife Biologist	831-254-9750	jtomoleoni@usgs.gov
Brian Hatfield – Wildlife Biologist	805-305-2121	brian_hatfield@usgs.gov
Michael Kenner – UC Santa Cruz Marine Tech	831-254-5184	mkenner@usgs.gov, mkenner@ucsc.edu

-- Personnel qualifications --

Please provide a brief description of the following:

a) Method of training for all field personnel on the proper care and use of wild animals.

Only qualified veterinarians will perform transmitter implant surgery on sea otters. Veterinarians inexperienced in the procedure will first observe the surgery performed by an experienced veterinarian before performing the procedure him/herself. Only experienced personnel will directly participate in the capture and handling of sea otters. Less-experienced personnel will initially assist with other aspects of fieldwork (i.e. field observations and data collection) and when time allows will be trained by one or more of the experienced researchers in this study in the appropriate tasks of animal capture handling (first by watching experienced personnel conducting the technique, then by performing the technique under close supervision).

b) Person responsible for providing training and their qualifications.
Veterinarians and vet assistants will be trained by Dr. Mike Murray, senior vet of the Monterey Bay Aquarium's sea otter program. Dr. Murray has over 25 years of experience with sea otter medicine and has implanted hundreds with instruments over the years. Non-veterinary otter handlers and transporters will be trained and overseen by wildlife biologists Joe Tomoleoni and Brian Hatfield. Between them, they have over 40 years of experience observing, capturing and handling sea otters.

c) How employee performance will be evaluated on techniques including but not limited to capturing, handling, marking, physical examinations of animals, injection of harmless substances, blood sampling, non-major surgeries, and euthanasia.

Employee performance is constantly being evaluated by supervisors or more experienced personnel. If performance is sub-par, corrective action is taken by instructing the employee on the proper technique, or removing the employee from that particular role.

d) For the PI and co-PI, and anyone who will act in a supervisory role in the field, please complete the table below.

Name	Title	Experience/Qualifications
Joe Tomoleoni	Wildlife Biologist	10 years' experience observing, capturing and handling sea otters
Brian Hatfield	Wildlife Biologist	34 years' experience observing, capturing and handling sea otters
Michael Kenner	UCSC – Marine Tech	31 years' experience observing, capturing and handling sea otters

SECTION I: PROJECT DESCRIPTION, GENERALLY

PURPOSE OF STUDY

a) Describe the specific objectives of your study. Try to use terms and language that could be understood by a non-scientist.

Our overall goal in CA is to study the population status of endangered sea otters, which is a keystone species (in other words, without which the nearshore ocean ecosystem would be dramatically altered), in order to provide scientific information to management agencies and federal partners that they can consider when making decisions to positively affect the recovery of the southern sea otter population and improve ecosystem health. In order to achieve this goal our research will address these specific objectives: Document patterns of mortality in the sea otter population, including spatial and temporal trends in the cause of death, and compare to equivalent patterns detectable from beach-cast carcasses. Collect basic data on sea otter demography, health and behavior required to refine, update and further develop population models used for advising federal and state management agencies. Examine the inter-relationships between nutritional requirements, energetic expenditure, anthropogenic and environmental stressors, individual health and population performance.

b) Explain how the study will benefit wildlife, humans, or society. Benefits can include basic scientific knowledge; conservation and/or management applications for wildlife; wildlife habitat; wildlife or human health.

Sea otters are a keystone species. In other words, without them, the nearshore ecosystem would be dramatically altered. Sea otters benefit ocean kelp forests which nourish fish and other sea life important to wildlife health and human economic interests. Sea otters provide this benefit by acting as a main predator on sea urchins, which are capable of decimating kelp forests, as has been widely observed by scientists. Our work will contribute to basic scientific knowledge of sea otter individuals and populations as well as provide management agencies with tools for smarter, more effective goals and regulations.

c) Justify:

Rationale for the study of live animals: why must animals be studied rather than using computer models, habitat studies, etc.?)

Appropriateness of species to be studied

- Describe the biological characteristics of the animal species that make them suitable for this particular study. Cost should not be used as a justification, except as a means to choose among species that are equally suitable.
- Please explain how this work will benefit this particular species or other species that share its habitat or, if you are studying this species as a surrogate, how this species will serve as a model for the other species of interest.

Number of animals to be studied

- How did you determine the number of animals to be studied?

- When possible, include a statistical power justification of the sample size or yield of tissue per animal.
- For complex studies, providing a flow chart or table showing group size, time frame, study locations, and other information may be helpful in explaining how the total number of animals was determined.

***Rationale for the study of live animals*:**
In order to study the population health, demography, behavior and ecology of wild sea otters in their natural environment, there are no alternatives to the use of live animals. Any alternatives to the use of live animals, or more specifically the use of wild sea otters, would not achieve the research goals (to understand population dynamics, demographics, habitat use, health profiles and energetic constraints in free-living sea otters).

Appropriateness of species to be studied:
The research objectives of this project are specifically directed at understanding sea otter populations in California and addressing conservation questions about this species; no other animal species would be appropriate for this goal. Additionally, the sea otter represents an optimal sentinel (or indicator) of coastal ecosystem health, due to their sensitivity to pathogen and chemical pollution, their near-shore distribution, their extraordinary appeal to the general public (a fact which generates community support for monitoring efforts), and their tractability for observational study.

Number of animals to be studied:
A review of both the published results of past studies (citations below) and of our own unpublished data sets has provided us with fairly strong knowledge about the variation in data we can anticipate on population vital rates (e.g. survival, reproduction), behavior (e.g. diet and home range use) and individual health parameters (e.g. seroprevalence for various pathogens, tissue contaminant loads, etc.). Highly variable data can lead to statistically imprecise population-level estimates, but their precision can typically be improved by increasing the numbers of individuals in the population being sampled. Based on anticipated variances, we have proposed the minimum sample sizes sufficient (when combined with our existing samples) to obtain statistically informative results from the various analytical procedures we will conduct to achieve our objectives. Over the next 5 years we will capture up to 600 animals for flipper tagging and bio-sampling, in order to characterize basic measures of population health. Of these, we will apply surgically-implanted transmitters and bio-logging time-depth recorders (TDRs) to up to 300 animals, which will be used for analyses of behavior, diet, survival rates, reproduction, spatial contrasts of mortality patterns, and spatially-explicit, multifactorial epidemiological models. The total population size of the southern sea otter at present a minimum of 3,128 individuals, based on our most recent survey data. Our request to capture, tag, and bio-sample 600 animals over three years, assuming it is spread out as up to 120 animals per year, therefore represents less than 3.8% of the current total population each year. Our request to surgically-implant transmitters and TDRs applies to half this number, or less than 1.9%.

We do not present power analyses for practical reasons. While power analyses can be very useful for assessing the adequacy of a sample, in general power analyses require a greater deal of analyses than the actual data analysis itself. Proper power analyses consist of results of a range of hypothetical analyses, each with the same statistical complexity as the actual analysis, except for different hypothetical sample sizes. Although some simple power formulas exist, these are special cases that only apply to simple data analyses (e.g. analyzing the significance of a single mean or a difference of two means). General power analyses often require intensive computer simulations in order to evaluate how the outcome of analyses can change in correspondence to different sample sizes.

As a comparison, our proposed sample sizes are slightly less than the sample sizes for a recent ACUC with the University Santa Cruz, for a similar sea otter research program (400 animals across 3 years, or approximately 133 animals per year, representing approximately 4.2% of the total population at that time).

Citations of papers that provide estimates of sea otter vital rates and associated variances:

Eberhardt, L. L. 1995. Using the Lotka-Leslie model for sea otters. Journal of Wildlife Management 59:222-227.

Eberhardt, L. L., and K. B. Schneider. 1994. Estimating sea otter reproductive rates. Marine Mammal Science 10:31-37.

Gerber, L. R., T. Tinker, D. Doak, and J. Estes. 2004. Mortality sensitivity in life-stage simulation analysis: A case study of southern sea otters. Ecological Applications 14:1554–1565.

Jameson, R. J., and A. M. Johnson. 1993. Reproductive characteristics of female sea otters. Marine Mammal Science 9:156-167.

Riedman, M. L., and J. A. Estes. 1990. The sea otter, Enhydra lutris: behavior, ecology and natural history. U S Fish and Wildlife Service Biological Report 90:I-III, 1-126.

Riedman, M. L., J. A. Estes, M. M. Staedler, A. A. Giles, and D. R. Carlson. 1994. Breeding patterns and reproductive success of California sea otters. Journal of Wildlife Management 58:391-399.

Siniff, D. B., and K. Ralls. 1991. Reproduction, survival and tag loss in California sea otters. Marine Mammal Science 7:211-229.

Tinker, M. T., D. F. Doak, and J. A. Estes. 2008. Using demography and movement behavior to predict range expansion of the southern sea otter. Ecological Applications 18:1781-1794.

Tinker, M. T., D. F. Doak, J. A. Estes, B. B. Hatfield, M. M. Staedler, and J. L. Bodkin. 2006. Incorporating diverse data and realistic complexity into demographic estimation procedures for sea otters. Ecological Applications 16:2293-2312.

Tinker, M. T., J. Tomoleoni, N. LaRoche, L. Bowen, A. K. Miles, M. Murray, M. Staedler, and Z. Randell. 2017. Southern sea otter range expansion and habitat use in the Santa Barbara Channel, California. US Geological Survey Open File Report 2017-1001:76p.

ANIMAL SPECIES (Scientific and Common Name)	Number to be studied (Year 1)	Number to be studied (Year 2)	Number to be studied (Year 3)	Number to be studied (Year 4)	Number to be studied (Year 5)
Southern Sea Otter – *Enhydra lutris nereis*	120	120	120	120	120
*** NON-TARGET ANIMALS (Scientific and Common Name)**	**Potential Number Affected (Year 1)**	**Potential Number Affected (Year 2)**	**Potential Number Affected (Year 3)**	**Potential Number Affected (Year 4)**	**Potential Number Affected (Year 5)**
Sea Otter – *Enhydra lutris*	100	100	100	100	100

* **NON-TARGET ANIMALS** *include any non-study animals directly or indirectly affected by the research. Examples include the potential to live-capture or kill non-target individuals (e.g., loss of offspring due to taking of one or both parents) or disturb/harass other species during the research activity.*

NOTE: Species lists might include general descriptors such as "all native mammals" rather than an extensive list of individual species.

PERMITS: Identify all required permits or other forms of written authorization including protected species permits at the national and state or provincial levels (in the U.S.: Migratory Bird Treaty Act, Endangered Species Act, CITES, Marine Mammal Protection Act, and Wild Bird Conservation Act; Lacey Act; state permits for state-listed species); national and state/provincial protected areas permits (in the U.S., National Wildlife Refuge System, National Parks, National Forest System, Bureau of Land Management; state permits for wildlife management areas, parks, or other protected areas). If the study will take place on private land please provide documentation of landowners permission.

Permit type or other form or written authorization	Permit number, if any	Expiration date (or if application or renewal application pending, date submitted)
US Fish and Wildlife, scientific research on marine mammal	Renewal of #MA672624-20	Submitted 8/10/2018

If your research requires federal or state permits, it is unlawful to begin work until all permits have been obtained. You may not start the work for which permits are required until the permits are issued, even if your protocol has been approved.

VETERINARY INVOLVEMENT

If your research entails a major procedure [As defined by the Guide to the Care and Use of Laboratory Animals (similar to AWA "major operative procedure defined above): "As a general guideline, major survival surgery (e.g., laparotomy, thoracotomy, joint replacement, and limb amputation) penetrates and exposes a body cavity, produces substantial impairment of physical or physiologic functions, or involves extensive tissue dissection or transection (Brown *et al*., 1993). Minor survival surgery does not expose a body cavity and causes little or no physical impairment; this category includes wound suturing, peripheral vessel cannulation, percutaneous biopsy, routine agricultural animal procedures such as castration, and most procedures routinely done on an "outpatient" basis in veterinary clinical practice."] or the use of controlled substances, detail the involvement of a veterinarian in the planning of the procedure(s). Will the veterinarian collaborate with you in carrying out the procedure(s)? If so, provide name, contact information, affiliation, and details of involvement.

Note*: Section 5 of the model Veterinary Practices Act endorsed by the American Veterinary Medical Association (AVMA) states that, "No person may practice veterinary medicine in the State except within the context of a veterinarian-client-patient relationship [VCPR] and that a VCPR cannot be established solely by telephonic or other electronic means." Be sure to define the method of interaction during the planning, collaboration, and advising stages of the project.*

Name: Dr. Mike Murray

Phone: 831-238-6924

Email: mmurray@mbayaq.org

Affiliation: Monterey Bay Aquarium

Details: Dr. Murray is a Senior Veterinarian with whom the project has benefitted from frequent in-person discussions and interactions. Dr. Murray is involved in all aspects of animal care, including pre-deployment planning as well as captures, deployment, and, when applicable, operative and post-operative care. During pre-deployment, when field operations are planned, Dr. Murray assumes responsibilities for contacting the various facilities capable of holding sea otters. As a best practice for prudence, he gives them a heads up when there is an outside chance we may be calling on them for assistance.

SECTION II: MAINTAINING WILDLIFE IN CAPTIVITY

TEMPORARY ANIMAL HOUSING

Will animals will be held in captivity temporarily but:

a) for more than 12 hours? (Animal Welfare Act)

YES	NO
☐	☒

b) overnight?

YES	NO
☐	☒

If you answered YES to either of the two questions, describe:

- *the planned duration of the captivity*
- *the temporary holding facilities you intend to use, specifying cage size/type:*
- *equipment that you intend to use;*
- *feeding strategies;*
- *plans for maintaining suitable environmental conditions, and*
- *release procedures.*
- *A photograph, drawing, or illustration of the holding facility may help to clarify your description.*

Description: Animals will not be held in captivity for more than 12 hours or overnight, unless a veterinarian determines the animal has a need for medical intervention requiring a longer stay. If necessary, distressed animals will be transferred to the nearest marine mammal rehabilitation or holding facility with sea otter holding capabilities, such as Monterey Bay Aquarium, California Department of Fish & Wildlife Marine Wildlife Veterinary Care & Research Center, The Marine Mammal Center, Aquarium of the Pacific, or Sea World San Diego. Transport, holding, and care protocols will be in accordance with the facility's standard operating procedures.

PERMANENT ANIMAL HOUSING

If animals are to be held permanently, describe:

- *duration of quarantine and diagnostic testing;*
- *acclimatization to captivity and the presence of researchers and lab techs;*
- *housing facilities including cage size/type;*
- *sanitation procedures;*
- *social grouping or solitary housing and the reasons for such housing;*
- *health monitoring procedures;*
- *list any ACUC approved SOPs to be followed for housing or husbandry.*

Description: NA

ANIMAL DIET

List food type (if applicable) and describe:

- *Feed and water method*
- *Frequency that the animal will be fed*
- *If food items or quantities other than the animal's natural diets will be used, please also answer "***SECTION III-DIET SUPPLEMENTATION OR ALTERATION.***"*

Description: NA

SECTION III: PROCEDURES OTHER THAN SURGERY

If you are planning activities not listed below, please describe all procedures under the section entitled **"OTHER."**

YES	NO	
☒	☐	**WILDLIFE CAPTURE (LIVE CAPTURE OR KILL TRAPPING)**

Describe

- *equipment to be used;*
- *planned duration of trapping/restraint;*
- *monitoring protocol/schedule for traps;*
- *how you will treat capture myopathy;*
- *potential for trapping non-target species;*
- *disposition of trapped animals; and*
- *if anesthesia or immobilization is planned please complete those sections of this form.*

Capture Techniques:

Individual sea otters will be captured either in tangle nets, underwater diver-held traps (Wilson traps), or hand-held dip nets. All methods are routinely used throughout the range of the sea otter population (U.S., Russia, and Canada). Recapture of individuals will most likely be by underwater diver-held traps.

Diver-operated Wilson Traps

Our primary capture method involves using diver-operated traps to capture resting sea otters. Shore spotters with high-powered spotting scopes relay information about target animals to the dive crew. Divers work in pairs and each diver has a trap with a capacity for one adult sea otter, 2 juveniles, or a mother/pup pair. Otters must be resting (preferably sleeping) for this method to be successful. Divers use closed-circuit oxygen rebreathers and electric propulsion vehicles to maneuver the traps underneath the floating sea otters and engulf them with a net bag, which is closed by a purse line. The divers keep the animal and trap on the surface until the transport vessel arrives and the otters can be transferred to a sliding-lid capture box. Our research group has captured >600 sea otters in California, and >1000 sea otters in California, Alaska, Washington, Canada, and Russia combined, using diver operated Wilson traps with no trap-related mortalities. This method is highly selective, with zero chance for taking non-target species. Furthermore, this method allows us to target specific individuals, minimizing disturbance or harassment to non-target individuals.

Tangle Nets

Tangle nets are surface floating, un-weighted nets set in near shore waters in the vicinity of sea otters. Nets are typically 100 m long by 5 m deep (stretch mesh of about 22 cm), but may be modified to capture in shallow water. Each tangle net consists of stretch mesh hung between a positively-buoyant float line and a slightly negatively buoyant led line, and are suspended between large float buoys at each end which are anchored in place (ensuring sufficient anchor-line scope to avoid dragging the buoys below the surface under any tide or current condition). Nets are set out by a tending skiff and then monitored by the skiff and/or shore-based observers. When one or more otters become entangled in the net, the skiff returns and extracts the otter(s), transferring them to capture boxes for transport to the processing site. The deployment of nets is made under due consideration of predicted weather conditions: nets will not be set during periods of weather or sea state that may preclude their tending. In an effort to minimize the chances of entanglements or by-catch of non-target species: 1) two shore-based observers with telescopes (instead of just one) will monitor a deployed net, with one observer continuously scanning the float line of the net in order to detect entanglements, and the second observer scanning the entire vicinity around the net for any marine mammal activity.

Dip Nets

Dip-netting is a procedure where sea otters are dipped out of the water with a large fish-landing net. Open-water capture takes place from the bow of a small skiff, with one net handler and a vessel operator. This method is usually used to capture young animals. USGS personnel have been involved in the capture of >250 sea otters using dip-nets with no dip-net-related mortalities. There is virtually no potential for bycatch with this technique.

YES	NO	
☒	☐	**ANIMAL TRANSPORTATION**

Describe

- *how animals will be transported from a capture location to a field camp or processing site or facility and returned; and*
- *if an animal (live or dead) is to be transported from the field, describe measures to be taken to avoid potential disease transmission to researchers and other animals.*

Description: The processing facility will generally be on a boat or a shore-based facility easily accessible by boat. Transport of animals from capture sites will therefore usually be by small boat and animals will be transported in an "otter box" as described below. In some instances, transport by vehicle may be preferable when reduced transit time or calmer conditions may be achieved. In this case, the animal in the otter box will be transported in an air-conditioned vehicle. "Otter Boxes" are rinsed and/or hosed clean between uses. Dead animals are not transported in the boxes. There is no precedence for transmission of disease from live sea otters to other animals or humans other than the possibility of infection from a puncture bite, however, standard surgical protocols – mask, goggles and nitrile gloves – are used during veterinary procedures.

YES	NO	
☒	☐	**PHYSICAL RESTRAINT FOLLOWING CAPTURE**

Describe

- *method(s) to be used;*
- *planned duration of restraint;*
- *equipment to be used, including dimensions of equipment if applicable;*
- *observation schedule during confinement;*
- *Provide detailed justification and protocol if animals are to be physically restrained for longer than 1 hour at a time.*

Description: Holding:

The sea otters are transferred directly from the Wilson Trap, Tangle Net, or Dip Net, to a specially designed "otter box." These boxes have been customized over many decades of sea otter capture and handling, and represent the best possible temporary holding container for sea otters. Box materials, dimensions, and accessories have been designed and approved by both sea otter biologists and sea otter veterinarians with decades of experience in handling and transporting wild sea otters.

The boxes are made of marine grade plywood with an epoxy coating to protect the otters and the box itself. The epoxy also creates a smooth surface on the interior, and makes the boxes easy to clean. Wood is a desirable material because it is strong and sturdy, but still soft enough that the most uncooperative otters can chew it without damaging their teeth. The interior dimensions of the boxes are 36"L x 17"W x 22"H, providing more than enough room for an adult male sea otter, or a female and large pup. The box features a sliding plywood lid. By design, the walls and lid create a dark interior, which is believed by veterinarians and animal care experts, to have a calming effect on the animals inside. Our decades of field experience with these boxes have shown that the otters appear to be very calm once inside the box.

All 4 sides, and the bottom panel of the box feature 5/8" holes drilled at multiple levels for adequate ventilation. These holes serve another purpose though. The box may be floated in the ocean, alongside the boat, at any time. The holes allow water to enter the box, so that the otter can float inside the box. The cold seawater helps the otter thermoregulate, and helps to prevent any overheating that might potentially occur as a physiological response to the capture process.

Inside the box, a "false bottom" is installed. This is a PVC grate that allows refuse or materials such as feces to pass through the grate and exit via the bottom of the box, eliminating any chance of the material fouling the otter's fur. This keeps the interior of the box clean and tidy. Boxes also have canine "chew toys" (the kind you get at your local pet store) installed for the otters that like to chew. Chewing on a chew toy decreases the likelihood of the otters chewing on the wood box, while also giving them a distraction and reduces their anxiety while inside the box.

When otters need to be physically restrained (e.g. when being injected with the sedative) the procedure is done so in the safety of the otter box. A "stuff sack," which is a very soft cushion similar to a pillow but covered with a tough cordura exterior, is used to gently block the otter's head and shoulders while the vet administers the injection into the hindquarters. The process only takes a few seconds, and the otter usually uses the stuff sack as a chew toy.

Holding time:

Captured individuals will be transported from the capture location to the handling location in holding boxes that provide adequate ventilation. Ice or cold water will be provided as needed to keep the animals cool. Transport time will be kept to a minimum by co-locating capture vessels and handling/processing platforms. All animals will be released at or as near to their location of capture as is possible. Efforts will be made to process and release sea otters within 2 hrs of capture. The otters are not physically restrained for this entire time. Most of the time is spent in the safety and relative comfort of the otter box, or anesthetized. Animals are typically checked approximately every 15 minutes when inside the otter box.

YES	NO	
☒	☐	**EQUIPMENT DECONTAMINATION PROCEDURES**

Describe

- *where appropriate, the decontamination procedures for equipment that will be used to capture, transport, contain, etc. animals; and*
- *frequency of decontamination.*

Description: "Otter Boxes" are rinsed and/or hosed clean between uses. Dead animals are not transported in the boxes. There is no precedence for transmission of disease from live sea otters to other animals or humans via equipment.

YES	NO	
☒	☐	**PERSONAL PROTECTIVE EQUIPMENT (PPE)**

Describe all PPE that will be used by personnel including, gloves, respirators, goggles or faceshields, etc. If no PPE is planned, explain the likelihood of exposure to potential hazards (pathogens – including mode of transmission; bites, scratches, and stings), the potential consequences, and any other methods you intend to use to avoid the hazards or the consequences, such as physical means, prophylactic medicines, post-exposure treatment.

Description: Field crews will typically only use "stuff sacks" described above in conjunction with the "otter box" to safely contain animals. Elbow length leather gloves may be worn to aid with handling for sedation. Vet crew wear standard surgical PPE – goggles, mask and nitrile gloves.

YES	NO	
☒	☐	**MONITORING THE HEALTH OF CAPTURED ANIMALS**

Describe

- *observations planned for monitoring health of captured animals*
- *physiological parameters (e.g., temperature, pulse rate, respiration rate, capillary refill time) to be recorded;*
- *frequency of measurements;*
- *expected normal ranges for all physiological parameters monitored; and*
- *provide a protocol for addressing physiological parameters outside of normal ranges (e.g., how do you plan to treat hypothermia?).*

Description: Observations planned for monitoring health of captured animals: Animals are initially evaluated by field teams at the site of capture. Divers and boat tenders are all experienced sea otter biologists and are capable of recognizing overt anomalies in animal health. Should any be noticed, veterinarians at the shore/boat based veterinary care area are notified. Based on findings, a decision is made to either release the animal or continue transport to the vet facility. Sea otters are aggressive, dangerous carnivores and therefore thorough examination of an awake sea otter is not feasible; only the most apparent overt signs of abnormality are noted. Once sedated, the sea otter is subjected to a thorough physical examination by an experienced veterinarian. If practical, abnormalities are addressed. Beyond physical exams, clinical pathology parameters, such as blood glucose, blood gases, and limited hematological values are evaluated.
Physiological parameters (e.g., temperature, pulse rate, respiration rate, capillary refill time) to be recorded: Throughout the time period during which the sea otter is chemically immobilized, the following physical parameters are monitored: rectal temperature, pulse rate, respiratory rate, hemoglobin saturation (via pulse oximetry).
Frequency of measurements: Measurements are taken and recorded at a minimum of every 5 minutes, more frequently if directed by the attending veterinarian.
Expected normal ranges for all physiological parameters monitored: Temperature: 99-101 F; Pulse rate: 120-160 beats/min; Resp rate: 12-20 breaths/min; Hemoglobin saturation: 95-100%
Protocol for addressing physiological parameters outside of normal ranges: Hypothermia is rarely encountered in sea otters. When observed it is often associated with hypoglycemia. If low body temperature is noted, all cooling agents, such as ice, will be removed. Vigorous drying/rubbing of the skin and fur will occur. Inspired gas may be warmed; the otter placed on towels or blankets, and pre-warmed fluids administered as indicated. Hyperthermia is much more common in the sea otter. Attempts to prevent elevated body temperature start with the capture team. Unless the otter's transport is very short (this parameter is determined by factors such as otter activity, apparent body weight, struggling during capture, ambient temperature and sun exposure), the otter will be maintained in the water within the capture box for 10-15 minutes prior to transfer to the vet lab. If noted while immobilized, ice bags will be placed on the inguinal areas, ventral cervical, axillary space, and on the breathing tubes to cool inspired air. If these steps are unsuccessful, cold water enemas may be administered. Efforts to manage core body temperature start before the animal becomes hyperthermic; typically ice is placed on the inguinal area once temperature exceeds 100 F. Bradycardia (slow heart rate) will be managed as indicated by the veterinarian. Drugs, such as atropine may be administered as needed. Tachycardia (rapid heart rate) is also managed by the veterinarian. In most cases, this state is the result of inadequate sedation. It may be managed with increased drug doses and/or decreased external stimulation (ie, reduction of noise, ear muffs, covering the eyes). Decreased respiratory rate is also managed by the veterinarian. The most common method to manage this finding is to intubate the trachea and provide intermittent positive pressure ventilation. Rarely, chemotherapeutics such as doxapram may be indicated. Tachypnea, like tachycardia, is generally the result of inadequate sedation, and will be managed accordingly. Either states, increased heart or respiratory rates may also be managed by the addition of inhalant anesthetics, such as isoflurane. In the rare case in which an otter becomes markedly unstable and efforts to stabilize are unsuccessful, doses of naltrexone and flumazenil can be administered to reverse the effects of the sedative.

YES	NO	
☒	☐	**MARKING OR TAGGING**

Describe

- *marker type and why that particular type is to be used;*
- *mass of the device as a proportion of body mass;*

- *recommended device mass proportionate to body mass;*
- *method and mass of attachment method;*
- *expected effect, if any, on behavior, health, or social status of an individual.*

Description: Flipper Tags: Generally, all animals captured > 11 lbs (> 5.0 kg) will be visually tagged to prevent repeated sampling of the same individuals. Temple tags, used on the hind flippers, are 45 x 14 x 2 mm, and weigh ~7g (0.14% of body mass for the smallest otters). Each otter will be tagged with unique color/number (typically 2 tags per otter [1 per flipper], no more than 4 tags [2 on each flipper]). Because long-term tag retention rates are <100% (Ames et al. 1982, 1983) each sea otter may also be marked with a coded, passive transponder chip, implanted subcutaneously in the inner thigh. When flipper-tagging, holes are punched using a sterile leather punch (hole diameter <5mm). Flipper tags have been used extensively in sea otter research and rehabilitation effort without any observed deleterious effects. In addition, we request the ability to use newer electronic "smart" flipper tags in addition to, or in place of 1 or more of, the traditional Temple Tags described above. The smart flipper tags will be of comparable size and weight, but are still being developed and tested. These smart tags will have GPS capability, as well as network capability, allowing them to "talk" to the tags on other otters, thereby collecting, storing, and increasing opportunities for relaying information to a base station when in range. They are solar-powered and may include other additional sensors like an accelerometer, wet/dry switch, etc. These tags are being developed in a collaboration between USGS and NASA. Concurrent to tag development, different materials and form factors are being tested on captive sea otters at the Monterey Bay Aquarium. These smart tags will be capable of collecting geo-location data and/or conducting otter-shore or otter-otter communications, and we anticipate that eventually they will replace the implantable VHF transmitters as a less-invasive, primary means of sea otter tracking/monitoring. The form-factor and attachment method are similar to the temple tags, and these next-generation smart tags would only be deployed on wild otters (in addition to, or in place of, temple tags) after they have been tested and evaluated by a USDA-licensed research facility under the approval of the institution's IACUC. These experimental instruments will not be deployed on free-ranging sea otters unless the IACUC agrees that no significant negative effects were noted.
PIT Tags: Implantation of "passive integrated transponders", or PIT tags, may be done to facilitate identification in the event of external tag loss. PIT tags have been safely used in multiple species of all sizes, including sea otters, without deleterious effects to survival. 125 MHz tags, approximately 13 x 2mm, will be injected into the left inguinal area using a 12 gauge needle and syringe. Tag, needle, and syringe are gas-sterilized together in a package or come pre-sterilized from the manufacturer (Biomark, Boise, ID). PIT tags are encased in biocompatible glass, which protects the electronics while preventing adverse effects to the animal. All captured otters will be scanned prior to initiation of sampling/external tagging for identification and to access prior capture history.
VHF Radio Transmitters & Archival Time-Depth Recorders (TDRs): For some aspects of our research, use of electronic signaling tags is necessary. VHF radio transmitters (80 x 22 x 50mm, ~160g, Advanced Telemetry Systems, Isanti, MN) and time depth recorders (TDRs, 67 x 17 x 17mm, ~27g, Wildlife Computers, Redmond, WA) are standard instruments that are currently surgically implanted in sea otters. Radios are potted in a waterproof electrical resin and coated with a USP Class VI material (United States Pharmacopeia, Class VI requires the most stringent testing). TDRs are potted in a hydrolytically stable material and coated with a non-bioreactive coating. Instruments are gas-sterilized and sealed in surgical steri-peal pouches for storage until used. This procedure has been successfully completed on several hundred sea otters in Alaska and California with very low rates of mortality (< 0.2%). Together, both instruments will represent between 0.5% (in a large male) to 2% (in a 10 kg juvenile) of body weight.

YES NO

☒ ☐ **BLOOD SAMPLING**

Describe

- *needle gauge and length;*
- *collection site preparation;*
- *location of collection sites;*
- *sample volume;*
- *frequency of sampling(s);*
- *total samples per animal;*
- *how long an animal is retained for sampling; and*
- *indicate the percent blood loss per sample based on the animal's body mass, how fluid volume will be restored, and describe how animal(s) will be monitored for anemia.*

Description: 1.) If large samples are needed (eg >12 ml?), the best site to sample is the jugular vein. The simplest way to locate the jugular vein is to draw a straight line between the thoracic inlet and the corner of the mandible: The jugular vein runs just under the skin between these two points. The vessel may be difficult to visualize in otters with poor peripheral perfusion due to low blood pressure or in normal adult male otters due to their robust, muscular necks. In many cases, moistening the fur overlying the vein with a judicious amount of rubbing alcohol will aid in visualization.

2.) If smaller samples are required, the popliteal vein can be used along with physical immobilization. This vessel is best accessed from the medial aspect of the stifle joint. With the femur at a right angle to the pelvis and the tibia at a right angle to the femur, the phlebotomist grasps the proximal tibia placing the tip of the thumb over the medial tibial condyle and the remainder of the thumb along the long axis of the tibia. An appropriately sized needle (19 ga x 1.5" for an adult sea otter) is inserted (attached to syringe) perpendicular to the skin just medial and distal to the sesamoid bone in the medial head of the gastrocnemius muscle. When the thumb and otter's limb is properly positioned, the insertion point is at about the 10:00 or 2:00 position for the left and right legs respectively. In most cases the needle is advanced nearly to its complete length under slight negative pressure and then withdrawn slowly until the vessel is entered. The syringe should fill rapidly; a slow fill time indicates entry into one of the smaller vessels nearby. If fill time is delayed too much, clotting of the sample is likely. It is important to maintain digital pressure over the phlebotomy site for 2-4 minutes after withdrawing the needle to prevent hematoma formation. The most important aspect of the process is firm, resolute restraint in a consistent, reproducible orientations, as vascular access is totally blind.

3.) A third sample site is the anterior vena cava. This location is especially useful for obtaining blood samples from juvenile & neonate otters with small blood vessels. This technique is associated with increased risk due to the location of the vessel within the thoracic cavity making direct pressure hemostasis impossible. Properly performed, however, this approach provides a good blood sample from otherwise problematic individuals. As with other sampling methods, consistent positioning and good restraint are critically important. The anterior vena cava is best approached with the otter in sternal recumbency, restrained like a cat for jugular venipuncture. The front legs are extended and held off the edge of the table. The head is held firmly and extended with the nose point upward. The otter's body is pinned by the elbow to the restrainer's body. Using a 22-25 ga x 1.5" needle attached to a 1-6 ml syringe (patient size dependent), the thoracic cavity is entered at the junction of the sternum and the first rib. When approaching from the left side, the needle is directed towards the right elbow. If the approach is from the right side, the needle is directed parallel to the sternum. Immediately upon perforating the skin, a slight negative pressure is placed on the syringe. It is not unusual to locate the vessel as the needle is withdrawn. Slow, deliberate movements watching carefully for the "flash" of blood in the needle's hub increase success rates.

Samples are taken at the time of initial capture or recapture. Sampling will never occur more often than at 3-

month intervals. In practice, most recaptures are annual, or even less frequent. Blood is drawn via venipuncture, from the jugular vein. Isopropyl alcohol is used to clean the site and aid in the identification of the vessel. Animals are typically retained for no more than 2 hours, and every effort is made not to exceed this duration of holding time. Total sample may be up to 5% of blood volume, which is estimated to be 8% of body weight.

YES	NO	
☒	☐	**URINE/FECES SAMPLING**

If your method requires capture and holding of the animal, indicate the planned duration and method of holding.

Description: Urine may be collected via free catch, catheterization, or cystocentesis and feces via free-catch, manually collected per rectum, or opportunistically during processing but animals will not be held just for these collections.

YES	NO	
☒	☐	**OTHER BODY FLUIDS AND TISSUE SAMPLING**

Indicate

- *the type of substance, e.g. hair, feathers, scales, muscle tissue, abdominal fluid, swabs, bone marrow;*
- *method of collection;*
- *volumes per sample; frequency of sampling(s);*
- *length of time animal is held for sampling; and*
- *total samples per animal.*

Description: In addition to blood, urine and feces collections described above, other samples to be collected include microbiological cultures from nasal, rectal, oral and/or vaginal swabs, and three vibrissae, to be used for diet analysis via measurement of stable isotope ratios (vibrissae are readily extracted with a quick outward-tug). In the case of animals captured for telemetry instrumentation, a vestigial upper premolar will be extracted for age determination using standard dental elevators and forceps (Siniff and Ralls, 1988). Plugs of skin and tissue from flipper-tag punches will be retained for DNA testing and measurement of tissue contaminant levels. Milk samples will be collected opportunistically from lactating females using standardized techniques developed for marine mammals: prior to milk collection, an intra-muscular dose of oxytocin (1.0 ml of 20 IU/ml solution) will be administered, and the area around the mammary gland will be cleaned thoroughly using distilled water and dried with a clean towel. Having modified a large gauge syringe by cutting off the tapered end, the open mouth of the syringe will be placed over the nipple and, by drawing back the plunger, milk will be expressed and collected: we will attempt to collect a minimum of 1 ml and a maximum of 20 ml from each lactating female. As with all sampling and instrumentation, every effort will be made not to hold animals more than 2 hours.

YES	NO	
☒	☐	**BEHAVIORAL OR OBSERVATIONAL STUDY (WITHOUT SIGNIFICANT RESTRAINT OR NOXIOUS STIMULI)**

Describe

- *procedure including frequency, duration of each observational session;*
- *number of observers;*

- *distance from animals; and*
- *type of equipment to be used.*

Description: Monitoring of study animals by radio telemetry and direct observation is non-invasive, and causes no distress to the subjects. The researchers will regularly cover the study area, by vehicle and/or by boat, in order to gather resights (i.e. new sample survey information on a previously sampled animal) of all tagged and instrumented otters: the primary purpose of this procedure is to monitor the survival, reproductive status and movement of study animals. Observers typically work singly or in pairs and remain 50 to several hundred meters from the study animal. A resight will consist of determining an otter's location by triangulation from the transmitter signal and, if possible, by making a visual sighting. Radio instrumented otters are to be located using programmable scanning receivers (Advanced Telemetry Systems, Isanti, MN), and identified using binoculars and high powered spotting scopes (Questar Corp., New Hope, PA). When an otter is located, the researcher will record its exact position as GPS coordinates. Other data recorded at each resight will include number of other otters with the subject animal, reproductive status (i.e. whether or not females have pups), behavioral state, presence or absence of a kelp canopy, water depth and distance from shore. A resight for each study animal will be obtained every 2-3 days, weather permitting. Researchers will also collect data on diet and foraging behavior by direct observation of feeding otters. In this procedure, the study animal is located (as described above) and observed using a Questar spotting scope (at 50x or 80x magnification). The data to be collected include the duration of each dive and subsequent surface time; whether or not the dive was successful; prey type; number and size of prey items caught; prey handling time, and various other information (as described in the documentation for the USGS-WERC sea otter database). Foraging data will be collected from all instrumented study animals on an opportunistic basis, although every attempt will be made to obtain roughly equivalent quantities of data from each animal, and particularly from animals with an active (i.e. data-collecting) TDR.

Data on activity budgets of study animals will be obtained by recording the behavior of a focal animal at 10 minute intervals over a 24 hour period: details of this method are provided elsewhere (Ralls and Siniff, 1990). Behavior will be recorded following the templates provided in the documentation for the USGS-WERC sea otter database.

YES NO

☐ ☒ **BEHAVIORAL OR OBSERVATIONAL STUDY (WITH SIGNIFICANT RESTRAINT OR NOXIOUS STIMULI)**

Describe

- *restraint procedure;*
- *equipment;*
- *duration;*
- *frequency;*
- *type of noxious stimulus;*
- *methods used to monitor animals for pain or distress*
- *methods to minimize pain or distress, if any; and*
- *scientific justification for the degree of restraint and/or noxious stimuli.*

Description: NA

YES NO

☐ ☒ **DIET SUPPLEMENTATION OR ALTERATION**

If food items or quantities other than the animal's natural diets will be used, describe

- *diet items and quantities;*
- *purpose for dietary change;*
- *planned duration;*
- *anticipated nutritional deficit/adverse effect;*
- *weight monitoring of animal(s);*
- *amount of weight gain or loss that will be allowed; and*
- *monitoring protocol/schedule for effects;*
- *planned diet for animal's whose natural diet is live prey. For these cases. How will the adequacy of diets other than live prey be assessed?.*

Description: Captive stay is brief (typically < 2 hours) so food and water are not provided.

YES NO

☒ ☐ **FOOD AND/OR WATER DEPRIVATION**

If food or water will be restricted or withheld, describe

- *duration of restriction or deprivation;*
- *frequency of deprivation;*
- *reason(s) for deprivation;*
- *monitoring protocol of animal(s);*
- *amount of weight loss that will be allowed;*
- *anticipated deficit/adverse effect; and*
- *monitoring protocol/schedule for effects*

Description: Captive stay is brief (typically < 2 hours) so no food and water are provided.

YES NO

☐ ☒ **INDWELLING CATHETERS OR IMPLANTS**

Describe

- *type;*
- *size;*
- *duration of use;*
- *maintenance and monitoring protocol/schedule; and*
- *if implantation requires a surgical protocol please complete Section VIII*

Description: NA

YES NO

☐ ☒ **ADMINISTRATION OF PARALYTICS (OTHER THAN IN THE COURSE OF SURGERY)**

Describe

- *agent;*
- *dose (mg/kg);*
- *route of administration;*
- *frequency of administration;*
- *duration of paralysis; and*
- *if used in conjunction with a procedure(s) involving potential pain, how will the presence of pain, depth of anesthesia, degree of analgesia be assessed?*

Description: NA

YES NO

☐ ☒ **ADMINISTRATION OF ANESTHETICS (OTHER THAN IN THE COURSE OF SURGERY)**

Describe

- *agent;*
- *dose (mg/kg);*
- *route of administration (manufacturer & model of equipment);*
- *duration of anesthesia;*
- *method of monitoring anesthesia;*
- *maintenance/monitoring procedures to ensure normal body temperature is maintained in the animal;*
- *procedures to be used in case of anesthetic emergency over-dose;*
- *monitoring protocol to ensure animal's complete recovery from anesthesia; and*
- *if by inhalation, the method of scavenging waste anesthetic gas/fumes; or*
- *if injectable agent(s) are not commercially prepared and sterility guaranteed please describe method used to assure the agent's sterility when injected.*

Description: NA

YES NO

☐ ☒ **ADMINISTRATION OF ANALGESICS (FOR OTHER THAN POST-SURGICAL PAIN RELIEF)**

Describe

- *agent;*
- *dose (in mg/kg);*
- *route of administration; and*
- *frequency, and duration of use.*

Description: NA

Yes No

☒ ☐ **USE OF CONTROLLED AND/OR PRESCRIPTION SUBSTANCES**

Irrespective of source, describe

- *source of substances;*
- *record keeping;*
- *storage; and*
- *precautions taken to avoid unauthorized access.*

Description: Source of substances: Controlled drugs are obtained from Central Avenue Pharmacy, Pacific Grove, CA.
Record keeping: Records are maintained in accordance with regulations established by the federal Drug Enforcement Agency, California Board of Veterinary Examiners, and California Board of Pharmacy. Records are maintained by both permit holder and the DEA license holder.
Storage: Controlled substances are stored in accordance with regulations. They are maintained under lock and key (maintained by attending veterinarian). As indicated, Class 5 safe is used to store controlled drugs.
Precautions taken to avoid unauthorized access: Only licensed veterinarians, veterinary technicians, and veterinary assistants have access to controlled drugs. Inventory is maintained and monitored by DEA license holder. All controlled drugs are maintained under lock and key by the DEA license holder.

YES NO

☐ ☒ **ADMINISTRATION OF DRUGS, TOXINS, REAGENTS, CELLS, ETC. (OTHER THAN ANALGESICS, ANESTHETICS, OR PARALYTICS)**

Describe

- *agent;*
- *dose (mg/kg);*
- *diluent;*
- *route of administration;*
- *equipment to be used for administration;*
- *frequency of administration;*
- *length of time animal maintained under influence;*
- *anticipated deficit/adverse effect, if any;*
- *monitoring protocol/schedule for effects;*
- *monitoring procedures to ensure cell lines have been screened for rodent pathogens; and*
- *if injectable agent(s) or silastic implant(s) are not commercially prepared and sterility guaranteed, describe method used to assure the agent's sterility when injected.*

Description: NA

YES NO

☐ ☒ **SURVIVAL SURGERY (MINOR)**

*If YES, complete **SECTION VIII Animal Surgery Information**.*

YES NO

☒ ☐ **SURVIVAL SURGERY (MAJOR, SINGLE)**

If YES, complete ***SECTION VIII Animal Surgery Information****. A major operative procedure is one that enters a body cavity. (For example, implanting a telemetry device into the body cavity constitutes a major operative procedure).*

YES NO

☒ ☐ **SURVIVAL SURGERIES (MAJOR, MULTIPLE)**

If YES, complete ***SECTION VIII Animal Surgery Information****. You must provide additional justification to perform multiple major operative procedures on one animal. Removal of telemetry devices is an acceptable reason.*

YES NO

☐ ☒ **NON-SURVIVAL SURGERY** *If YES, complete* ***SECTION VIII Animal Surgery Information****.*

YES NO

☐ ☒ **DEATH AS AN ENDPOINT**

- *If the protocol involves observing or studying the animal until death occurs you must provide scientific justification as to why an earlier endpoint is not acceptable in* ***Section IV, Alternatives to Procedures that Cause Pain or Distress****.*
- *If collecting the animal by shooting, lethal trapping or other means, describe the method of euthanasia or humane killing to be used in* ***Section VII, Euthanasia and Human Killing****.*

YES NO

☐ ☒ **OTHER**

Describe any other procedure to be administered not previously addressed.

Description: NA

SECTION IV: ALTERNATIVES TO PROCEDURES THAT CAUSE PAIN OR DISTRESS

The Interagency Research Animal Committee (IRAC), Animal Welfare Act (AWA) and its implementing regulations, and the Public Health Service Policy (PHS) ALL require that the principal investigator consider alternatives to procedures that may cause more than a momentary or slight pain or distress to the animal. The term “distress” is not defined in any of the resources above, however, the IRAC’s *U.S. Government Principles for the Utilization and Care of Vertebrate Animals Used in Testing, Research, and Training* states that, “Unless the contrary is established, investigators should consider that procedures that cause pain or distress in human beings may cause pain or distress in other animals.”

In the ILAR Guide to the Care and Use of Laboratory Animals (2011), the term distress is defined as “…an aversive state in which an animal fails to cope or adjust to various stressors with which it is presented….[although it] …may not induce an immediate and observable pathologic or behavioral alteration …” For the purpose of completing this table, please use this definition. You may also refer to Attachment A for category descriptions and examples.

Complete this table based on anticipated levels of pain and distress for your procedures.

	APHIS CATEGORY C NO PAIN, DISTRESS, OR THE USE OF PAINRELIEVING DRUGS	APHIS CATEGORY D TEACHING, RESEARCH, SURGERY, OR TESTS INVOLVING PAIN OR DISTRESS FOR WHICH APPROPRIATE ANESTHETIC, ANALGESIC, OR TRANQULIZING DRUGS WILL BE USED	APHIS CATEGORY E TEACHING, EXPERIMENTS, RESEARCH, SURGERY, OR TESTS INVOLVING PAIN OR DISTRESS FOR WHICH THE USE OF APPROPRIATE ANESTHETIC, ANALGESIC, OR TRANQUILIZING DRUGS WOULD ADVERSELY AFFECT THE PROCEDURES, RESULTS, OR INTERPRETATION OF THE TEACHING, RESEARCH, EXPERIMENTS, SURGERY, OR TESTS.
EXPECTED PRIOR TO PROCEDURE	☐	☐	☐
EXPECTED DURING PROCEDURE	☐	☒	☐
EXPECTED POST PROCEDURE	☐	☐	☐

Note: For all procedures you must describe any measures you will take to alleviate pain/distress as a part of your detailed description (if applicable).

Please provide a detailed description of all methods that may cause pain or distress (even momentary) to the animal under study and sources consulted to determine that alternative procedures are either not available or not acceptable.

For any method that may cause more than momentary or slight pain or distress to the animals, include in the description the effort made to identify and evaluate alternatives to these methods.

Note: If no published literature or sources are available, the researcher may describe discussions with other researchers with relevant experience and/or your own, unpublished observations. If the answer relies in whole or in part on discussions with other researchers, consider providing contact information for these individuals as the ACUC may wish to consult with one or more of them.

Description: The methods determined to be CLASS D procedures include the surgical implantation of VHF transmitters and time-depth recorders, biopsy sampling (during surgery) and the extraction of a vestigial premolar tooth for age estimation. See Section VIII - Surgical Procedure for full details of these methods. No feasible alternatives to the capture, immobilization and surgical implantation of telemetry instrumentation, or to age estimation via tooth sectioning and cementum analysis, have yet been developed for sea otters, based on our own expertise and on a review of the literature. Note: the details of the literature search results, and a full citation list of all relevant papers found, is attached to the end of this application.

Literature search

To satisfy the alternatives requirement, or in other words that no other alternative procedures to relieve pain or distress were acceptable, a literature search is required.

The Animal Welfare Act regulations suggest the use of the USDA National Agricultural Library's Animal Welfare Information Center, which has a compilation of databases [https://www.nal.usda.gov/publications]. However, these dozens of databases include many that are not useful for searching for alternatives and most are useful only for biomedical research. Do not feel constrained to use this particular resource; any relevant source is acceptable. The taxon-specific guidelines, for instance, include hundreds of species-specific references.

- American Society of Mammalogists Animal Care and Use Guidelines
- Ornithological Council Guidelines to the Use of Wild Birds in Research
- American Fisheries Society, American Institute of Fishery Research Biologists, and American Society of Ichthyologists and Herpetologists Guidelines to the Use of Fishes in Research
- American Society of Ichthyologists and Herpetologists Guidelines to the Use of Amphibians and Reptiles in Research

Describe your search strategy by:

- Identifying the sources of information or databases used
- The date or dates of your search
- Your key words
- Summarize the search results

Description: Sources: BIOSIS and Web of Science
Date of Search: 30 October, 2018
Key Words: Sea Otter - anesthesia, Sea otter - immobilization, Sea otter - neuroleptanalgesia
Relevant Results:

Arnemo, JM, P Dypsund, et al. (1997). "Surgical implantation of radio transmitters in wolverines." Norsk Veterinaertidsskrift **109(2): 103-104.**

Kollias, GV, N Abou-Madi (2014) "Procyonids and Mustelids" **In** Zoo Animal and Wildlife Immobilization and Anesthesia, 2nd Edition, Editor(s): G West, D Heard, N Caulkett. Pgs: **607-617**

Monson, DH, C McCormick, and BE Ballachey (2001). "Chemical anesthesia of northern sea otters (Enhydra lutris): Results of past field studies." Journal of Zoo and Wildlife Medicine **32(2): 181-189.**

Silveira, L, MM Furtado, et al. (2011) "Tagging Giant Otters (Pteronura brasiliensis) (Carnivora, Mustelidae) for Radio-Telemetry Studies" Aquatic Mammals **37(2): 208-212.**

Williams, TD., Sawyer, DC. (1996). "Chemical restraint and anesthesia of sea otters affected by the oil spill in Prince William Sound, Alaska." Journal of the American Veterinary Medical Association **208(11): 1831-1834.**

Williams, TD, AL Williams and DB Siniff (1981). "Fentanyl and Azaperone produced neuroleptanalgesia in the sea otter Enhydra lutris." Journal of Wildlife Diseases **17(3): 337-342.**

SECTION V: TYPE, FREQUENCY, AND TREATMENT OF INJURIES

Describe the most likely forms of injuries to research animals, how frequent an injury (ies) is (are) expected to occur, and planned procedures to treat injuries. **Even if you do not intend or expect to injure an animal, you must describe potential injuries and expected methods of treatment(s).**

Description: Historically, the most common injuries to captured sea otters were broken teeth due to biting down on exposed metal such as on a trap or kennel door. We have eliminated most such exposed surfaces – covering Wilson trap frames with plastic tubing and replacing kennels with wooden boxes. Our experienced field personnel are also aware of the potential problem and actively discourage biting of hard surfaces by use of soft stuff sacks and by providing chew toys in the transport boxes. There is little that can be done for such injuries beyond prevention but they are not life threatening nor terribly debilitating. Many wild sea otters have broken teeth and are not obviously impaired.

SECTION VI. WHAT WILL HAPPEN TO THE ANIMALS AT THE END OF THE RESEARCH?

a) If you plan to release animals, describe the pre-release conditioning, the site and time (date and time of day) of release, and any permits required for such release. NOTE: the release of captive animals that is not a planned part of a manipulative study requires justification. PIs are directed to consult taxon-specific guidelines regarding precautions for the release of captive individuals.

- American Society of Mammalogists Animal Care and Use Guidelines
- Ornithological Council Guidelines to the Use of Wild Birds in Research
- American Fisheries Society, American Institute of Fishery Research Biologists, and American Society of Ichthyologists and Herpetologists Guidelines to the Use of Fishes in Research
- American Society of Ichthyologists and Herpetologists Guidelines to the Use of Amphibians and Reptiles in Research

Description: Subject animals will be released immediately after processing – generally within 2 hours of capture.

b) If you plan to retain the animals for future research, when will you submit a protocol for the next research activity? Briefly describe that planned research activity.

Description: NA

c) If you plan to donate the animals to a zoo, captive-breeding program, or other arrangement entailing continued captivity, please describe the place where the animals to which the animals will be donated. Has this institution or organization agreed to accept the animals?

Description: NA

d) If you plan to euthanize the animals, describe the method of euthanasia to be used in the **Section VII, Euthanasia and Humane Killing**.

Note: In some instances, the landowner or federal agency (such as the National Park Service) may retain ownership of animals, specimens, or samples. In such cases, consult with the landowner or agency as to disposition.

SECTION VII: EUTHANASIA and HUMANE KILLING

The American Veterinary Medical Association (AVMA) published its revised *Guidelines for the Euthanasia of Animals* in 2013. As of September 1, 2013, OLAW required full implementation of the AVMA guidelines. Methods of euthanasia must comply with the AVMA guidelines unless the ACUC has approved a deviation. Deviations must be scientifically justified. Such a request for deviation is consistent with the AVMA guidelines which recognize that ending the life of wild animals in field settings might more appropriately be considered humane killing than euthanasia (AVMA pg. 81). Although the AVMA guidelines expressly do not apply to humane killing, methods considered acceptable therein are also acceptable and preferred for humane killing where possible. Under PHS Policy (section C.1.g), the ACUC has the authority to approve killing techniques not recognized as forms of euthanasia by the AVMA. Examples of other methods used for euthanasia or humane killing include those approved by the American Society of Mammalogists, the Ornithological Council, and the American Society of Ichthyologists and Herpetologists.

Whether euthanasia or humane killing, it is expected that investigators will use the most humane technique(s) feasible that is also consistent with study objectives.

Even if you do not intend to end animals' lives at any point in your project, a method of euthanasia or humane killing **must be listed** in cases of emergency except in instances where permits or statutes prohibit the killing of individuals of the species involved. If euthanasia or humane killing is prohibited by law or by permit conditions, provide supporting documentation.

YES	NO	
☒	☐	Does the project involve planned (or an emergency plan) euthanasia?
		If yes, which reference guidelines are used?

☐ AVMA (Specify revision year) ______________

☒ Other (Specify) American Association of Zoo Veterinarians

Describe the method of euthanasia.

Description: Euthanasia is not proposed or expected for this research. In the event that emergency euthanasia becomes necessary, euthanasia will be conducted by a qualified veterinarian following the protocol outlined below. Any euthanized animals, or tagged animals that die in the wild and are retrieved, will be necropsied as part of the ongoing pathology program at the CDFW and UC Davis (for which separate IACUC protocols exist).Euthanasia will only be considered in cases of immediate relief of irreversible pain and suffering from which return to the wild is considered inhumane. Other options, including therapeutic intervention and transfer to an authorized rehabilitation facility capable of managing sea otters (ie, Monterey Bay Aquarium Sea Otter Program) will be considered prior to euthanasia. Authorization for euthanasia must be obtained from both the attending veterinarian and the permit holder. As a result of the relatively precarious status of most sea otter populations, pre-euthanasia planning must include the collection of a variety of ante-mortem biologic samples, such as blood, urine, and potentially other tissues associated with research oversight committee-approved requests for biological samples. Additionally, preparations should be made to integrate the carcass into the necropsy database being developed under the leadership of the Marine Wildlife Veterinary Care and Research Center (MWVCRC) in Santa Cruz, CA (831-469-1719). The use of a consistent and thorough necropsy procedure results in the collection of a consistent sample set, which can then be compared to data from other sea otters. In order to safely and humanely euthanize a sea otter, some form of chemical restraint is recommended. This immobilization facilitates the collection of appropriate biological specimens, such as blood and urine antemortem. A combination of fentanyl citrate (0.22 – 0.33 mg/kg) and midazolam or diazepam (0.07 –0.11 mg/kg) administered intramuscularly will typically result in appropriate immobilization at the lower dose and actual anesthesia at the higher dose within 10 minutes of administration. These compounds are both controlled substances, and therefore must be handled, stored, and administered in accordance with provisions of state and federal law. After the injection is administered, the sea otter may be transferred into a kennel, capture box, or left within the net basket until sedated. Once the otter is adequately sedated, it may be placed in dorsal recumbency for access to the vascular system for euthanasia. After ante mortem sampling has been completed, the sea otter may be euthanized with a commercially available euthanasia solution containing sodium pentobarbital (a controlled substance and managed in accordance with state and federal law) given at a rate of 1.0 ml per 2-5 kg body weight, but typically not less than 3.0 ml. In most cases, the compound is administered intravenously via the jugular veins that are easily identified on the ventro-lateral aspect of the neck between the angle of the jaw and the thoracic inlet. A wetting agent, such as isopropyl alcohol, will aid in the identification of the vessel. Under some circumstances, direct intra-cardiac administration of euthanasia solution is preferable. Typical of the mustelids, the heart is located in the caudal aspect of the thoracic cavity, just cranial to the manubrium. As the sea otter's thorax is dorso-ventrally compressed, an apical heartbeat is generally easily visualized in the dorsally recumbent animal. An appropriately-sized needle, typically 22-20 ga 1.5-2.0 inch, may then be inserted between the ribs on either side just cranial to the site of the apical heart beat. Aspiration will confirm entry into one of the cardiac chambers, and the euthanasia solution is to be administered slowly. If no blood is recovered upon aspiration, the needle should be repositioned to assure entry into a cardiac chamber. It should be noted that the chemical characteristics of the euthanasia might render the heart difficult to assess during necropsy when the solution is administered via intra-cardiac route. The very dense pelage of the sea otter is a very effective insulator, and as such cooling of sea otter carcasses to slow autolysis may be problematic. Bodies should be protected within appropriately sized plastic bags and immediately immersed in iced water or they may be placed in a freezer for 2-3 hours to accelerate cooling. Once core body temperature has reached an appropriate level, typical refrigeration is adequate.

References

1. Guidelines for Euthanasia of Nondomestic Animals. American Association of Zoo Veterinarians, 2006.
2. Guidelines for Zoo and Aquarium Veterinary Medical Programs and Veterinary Facilities. American Association of Zoo Veterinarians, 1999.
3. Burns RB, McMahan W: Euthanasia methods for ectothermic vertebrates. In: Bonagura J (ed). Current Veterinary Therapy XII. WB Saunders Co, Philadelphia, PA, 1995, 1379-1381.
4. Reilly JS. Euthanasia of animals used for scientific purposes. "Australian and New Zealand Council for the Care of Animals in Research and Teaching.", 2nd ed, 2001: 85-86

YES	NO	
☐	☒	Does the project involve planned (or an emergency plan) humane killing?

If yes, please list the reference guidelines used and describe the method of humane killing.

Description: Click or tap here to enter text.

Describe the method used to ensure the animal will not revive and method of disposal of remains.

Description: Click or tap here to enter text.

YES	NO	
☐	☒	Is euthanasia or humane killing prohibited by law or by permit conditions?

If yes, please attach supporting documentation with this ACUC.

SECTION VIII: ANIMAL SURGERY INFORMATION

The term "surgery" is not defined in PHS Policy or the Animal Welfare Act regulations. The latter defines the term "major operative procedure" as any surgical intervention that penetrates and exposes a body cavity or any procedure which produces permanent impairment of physical or physiological functions. There is no definition of minor operative procedure; presumably, it is any procedure that does not penetrate or expose a body cavity or that does not produce permanent impairment of physical or physiological functions.

For the purposes of wildlife research, it is important to recall that the field studies exemption does not pertain to studies that involve "an invasive procedure, harms, or materially alters the behavior of an animal under study." The term "invasive procedure" is not defined in the Animal Welfare Act regulations. It is not clear if a minor operative procedure is considered invasive. However, OLAW recognizes the authority of the ACUC to determine whether specific manipulations used in research are major operative procedures and, given that neither OLAW nor APHIS has defined invasive procedure, it is reasonable to conclude that both agencies extend the authority to ACUCs to define invasiveness. The ACUC's determination must be based on a detailed description of the procedure and the anticipated or actual consequences, as characterized by the investigator. In some cases, the classification by the ACUC of a procedure as major or minor may be readjusted post-procedurally depending on clinical outcome. If the ACUC, after thorough review, determines that the surgical procedure only penetrates but does not expose a body cavity and that the procedure does not produce substantial impairment, the ACUC may conclude that it is not a major operative procedure. Any laparoscopic surgery that produces substantial impairment of physical or physiological function must be considered a major operative procedure. Whether the laparoscopic procedure is classified as major or minor, the ACUC must ensure that the appropriate analgesia, sterile technique, and perioperative monitoring is employed.

☐ Check here if no surgery is planned.

ANIMAL SPECIES (Scientific and Common Name)	Number that will be subjected to surgical procedure	S = Survival N = Non-survival	Surgery Location (Anatomic)
Southern Sea Otter – *Enhydra lutris nereis*	300	S	Abdominal cavity

Pre-operative Procedures and Care

a) Have obviously unhealthy or compromised animals been exempted from surgery?

Yes ☒ No ☐

If no, explain the rationale for performing surgery on obviously unhealthy or compromised animals.

Description: NA

b) Identify the individual responsible for evaluating pre-operative health status of animals.

Name: Dr. Mike Murray

Phone: 831-238-6924

Email: mmurray@mbayaq.org

Affiliation: Monterey Bay Aquarium

c) Provide a brief description of all pre-operative procedures and care.

Include

- *withholding of food and water;*
- *pre-operative antibiotic/therapeutic drug/fluid administration (agent, dose in mg/kg);*
- *route of administration, frequency, duration of treatment; and*
- *preparation of surgical site (e.g., clipping, use of antiseptic scrub/solution, etc.).*

Description: Since post capture holding time is minimal, no food or water is offered. Intramuscular injections of fentanyl and midazolam are administered separately with different syringes at dose rates adjusted to the purpose of handling. Darting is not used because otters are usually in the water and the risks of drowning or ‘struck and loss’ are too great. We use target dose rates of 0.33 mg/kg of fentanyl and 0.11 mg/kg of midazolam for surgical procedures, and 0.22 mg/kg fentanyl and 0.07 mg/kg of midazolam for non-surgical, biological sampling procedures as recommended by Monson et al. (2001). If anesthesia is not complete after approximately 15 minutes, additional fentanyl may be given. If 2-times the initial fentanyl dose is incrementally reached, and sedation is still not complete, the antagonist is given and the animal released without further handling (this is rarely observed). In the event of excessive tremors or convulsions, additional intravenous midazolam may be administered. Inhalant agents, such as isoflurane or sevoflurane, may be used as needed should anesthetic depth be deemed inadequate by the attending veterinarian. Also, based on the best judgment of the attending veterinarian, local anesthetics such as bupivacaine may be applied when potentially painful procedures are considered in the case of animals that are immobilized with lower doses or when anesthetic depth be deemed inadequate. Consistent with sound veterinary surgical practice, abdominal surgery, including implantation of VHF and/or TDR’s is done with aseptic technique. Modifications of traditional methods are necessary, however, in order to accommodate the need for immediate post-operative return to the wild and preservation of the integrity of the sea otter’s pelage due to its importance in thermoregulation. Rather than shaving the fur from the surgical site, the fur overlying the ventral midline is parted with a fine-toothed comb and held in place with a combination of water soluble, sterile surgical lubricating jelly and aqueous 10% solution of povidoneiodine.

d) Describe the facility or the area where the surgery will be performed:

Include

- *how it is prepared before each surgery;*
- *how surgical instruments are prepared; and*
- *how individuals responsible for surgery prepare themselves.*

Description: For captures in the vicinity of Monterey, surgeries and animal processing will be done in the state-of-the-art Animal Health Lab at the Monterey Bay Aquarium. For captures in more remote locales, surgeries may be conducted in an advanced mobile vet lab (provided by the California Department of Fish & Wildlife) or on a large research vessel in even more remote areas. In conformity with established veterinary surgery protocols, surgical surfaces and surroundings will be disinfected and instruments autoclaved or cold disinfected prior to surgery. Veterinary surgeons will scrub, and wear proper surgical attire and nitrile gloves.

SURGICAL PROCEDURES

a) Provide a brief description and/or citation of methods for all surgical procedures to be performed.

Include

- *incision site;*
- *procedures to be performed;*
- *anticipated duration of procedure; and*
- *method of wound closure including type and size of suture/staples.*

Description: VHF transmitters and TDRs are internally implanted, rather than being externally attached as in many marine mammal species, because 1) sea otters are unable to tolerate external attachments that might compromise their pelage (which is critical for thermoregulation), and 2) attached instruments similar to those used on pinnipeds would compromise their swimming and foraging abilities because of their small size. Furthermore, because of the nature of sea otter grooming activity, they are capable of reaching and removing (or destroying) most existing types of externally-attached tags. Consistent with sound veterinary surgical practice, abdominal surgery, including implantation of VHF and/or TDR's is done with aseptic technique. Modifications of traditional methods are necessary, however, in order to accommodate the need for immediate post-operative return to the wild and preservation of the integrity of the sea otter's pelage due to its importance in thermoregulation. Rather than shaving the fur from the surgical site, the fur overlying the ventral midline is parted with a fine-toothed comb and held in place with a combination of water soluble, sterile surgical lubricating jelly and aqueous 10% solution of povidone iodine. Access into the abdominal cavity is through an appropriately sized (6-10 cm) incision through the linea alba. Individually sterilized VHF transmitters and/or TDR's are then placed directly into the abdominal cavity, or in the case of TDR's may be inserted into the adipose tissue stored in the falciform ligament. If deemed necessary by the surgeon a solution of diluted antibiotic may be infused into the body cavity prior to closure. During the course of abdominal surgeries, the veterinarian may obtain small samples (5 g or less) of liver and/or adipose tissue, using appropriate biopsy techniques. The liver may be biopsied via a laparotomy and the traditionally described guillotine method in which a ligature is placed around an appropriate liver margin, tightened, and the entrapped portion of liver excised. Minimally invasive surgical methods utilizing rigid endoscopic technology are also appropriate for smaller samples. In this technique, the peritoneal cavity is insufflated with gas, a rigid endoscopic telescope and clam-shell biopsy forceps are inserted through two aseptically placed trocar/cannulas. Under direct visualization, multiple, up to six, biopsies of the liver can be collected. Samples of adipose tissue (fat) may be collected during routine surgical procedures as needed. These samples of up to 5 gm weight may be harvested from either the subcutis or from the falciform ligament, which typically contains large quantities of fat. Since sharp dissection and excision of fat samples is typically utilized, appropriate attention to hemostasis will be employed. Liver samples are used for analysis of contaminant exposure, while fat samples can be used for fatty acid analysis, an analytical procedure that (in conjunction with stable isotope analysis of vibrissae samples) can be used to quantify individual diets. A multi-layer, typically consisting of 4 separate suture lines, linea alba, subcutaneous fat/muscle, subcuticular, and skin, closure is meticulously performed to assure a water-tight seal, as well as to mitigate the potential for dehiscence either due to technique or self-mutilation. A sterile, mono-filament suture which is minimally reactive, provides adequate longevity, yet is absorbed over time is used to close surgical incisions. In addition to the process described above, additional safeguards are applied during instrument extraction/replacement surgeries. Since surgeries of this nature are more invasive with larger incisions, and greater duration, additional prophylactic measures are taken. In addition to the surgical drapes attached to the skin a secondary sterile draping system is utilized being affixed to either the subcutis or through a specialized sterile wound retractor. A broad spectrum, extended duration antibiotic is administered in conjunction with surgery. Any significant pathology encountered intra-operatively will be investigated within the limits of the patient's well being. A record of the surgical procedure and associated findings is completed following each procedure.

b) Describe procedure(s) employed to ensure aseptic technique is maintained throughout surgical procedure.

Include

- *sterilization method used for instruments, equipment and supplies;*
- *sterilization methods such as the use of sterile gloves, gowns, drapes, mask, cap, sterile implants, and sterile suture/closure material; and*
- *if same surgical instruments are used for multiple animals, describe how the instruments are managed to assure continued sterility.*

Description: Aseptic surgery performed on sea otters will be performed in an appropriate dedicated surgery area. In these cases, only appropriate facilities as determined by the attending veterinarian shall be utilized. Surgical procedures are to be performed by or under the direct supervision of licensed veterinarians with experience in sea otter medicine and surgery. Veterinary training will take a secondary role to the well-being of the sea otter patient. Appropriate care in the aseptic preparation of surgical sites, instruments, and surgeon consistent with accepted "standards of care" for practicing veterinary clinics is to be applied. An exception to this standard is the need to maintain thermal regulatory abilities within the sea otter. As a result, in most cases fur is not to be shaved from surgical sites. Instead, a mix of povidone-iodine solution and sterile water-soluble lubricating gel is used to create a "part" in the pelage. This part should extend down to skin level and be longer than the intended surgical incision. Adequate gel is to be applied to assure holding the fur back from the incision. In certain cases, it may be appropriate to secure secondary drapes to the subcutis intra-operatively to isolate the surgical area from the potential contamination associated with the pelage.

Sterilization method used for instruments, equipment and supplies: Three methods of sterilization will be employed. Durable instruments, such as surgical instruments will be steam sterilized in a standard autoclave. Efficacy will be monitored by indicator strips and the autoclave routinely evaluated using a biological indicator test system to confirm sterilization. Electronic instruments, such as radios and data collectors like TDRs, will be sterilized using a low temperature hydrogen peroxide plasma sterilization system. Delicate instruments which may be used multiple times but are not tolerant of autoclave temperatures and pressures, will be sterilized utilizing cold chemical sterilization with glutaraldehyde in accordance with manufacturer instructions. Single use, disposable items, such as scalpel blades, suture material, and surgical drapes will be purchased pre-sterilized and discards after use on a single patient. Sterilization methods such as the use of sterile gloves, gowns, drapes, mask, cap, sterile implants, and sterile suture/closure material: As described above, traditional aseptic technique will be employed whenever possible. Sterile instruments, gowns, and gloves will be utilized. The surgical theatre will be designed and managed in such a fashion as to minimize potential contamination of surgical sites and equipment. If same surgical instruments are used for multiple animals, describe how the instruments are managed to assure continued sterility: Instruments and equipment will be cleaned with soap and water and then sterilized in accordance with guidelines provided above. Items typically considered to be single use, such as scalpel blades, suture material, surgical gloves, and paper surgical gowns will be discarded after use on a single patient. Some more durable items, such as surgical towels, which are considered single use items in human medicine may be cleaned (laundered) and sterilized between patients. If cleaning and sterilization is not possible, they will be discarded between patients.

c) Identify all individuals performing surgery and describe their training and experience with regard to surgery involving the study species.

Name and Title	Surgery Performing	Experience

Michael J. Murray DVM, Jane Dunaway Director of Veterinary Services, Monterey Bay Aquarium	Primary veterinarian performing surgery and overseeing the medical aspects of sea otter handling.	Dr. Murray has been the primary veterinarian for most of the field work done on sea otters for the past 20 years and has worked in the field throughout the sea otter range from Russia to California. In his role at the Monterey Bay Aquarium, he has trained at least 10 veterinarians from other agencies and institutions on sea otter medicine and surgery. Other veterinarians will participate in sea otter work, however, their involvement will be directly overseen by Dr. Murray to minimize risk to the otter and maximize efficiency of the veterinary lab.
Dave Casper, DVM, Attending Veterinarian at UC Santa Cruz		Clinical veterinarian for 45 years with extensive experience in small mammal, avian, and marine mammal medicine. Management experience includes owning and operating own animal hospital and being head of department at the John G. Shedd Aquarium in charge of laboratory, veterinary services, and coordinating research. Research experience includes involvement with Long Marine Laboratory for the last 35 years assisting researchers with health care problems and field research, assisting with field research on bottlenose dolphins in Sarasota Florida, and Port O'Connor, Texas, and Beaufort, North Carolina, as well as coordinating the research program at the Shedd Aquarium. Holds position as UCSC attending veterinarian office at Long Marine Lab. A member of the UCSC Institutional Animal Use and Care Committee and the veterinarian/director for the UCSC marine mammal stranding network, and Director of the UCSC Vivarium. Have position as

		backup veterinarian at MBA for the last 10 years. Have worked on Sea otter captures for the last 12 years.
Claire Simeone, DVM, The Marine Mammal Center		Dr. Claire Simeone has seven years' experience working with marine mammals, including sea otters. She has provided medical care for sea otters both in a rehabilitation and captive setting, and has sedated roughly a dozen southern sea otters. She has performed both implant and explant surgeries under the observation of Dr. Mike Murray.
Shawn Johnson, DVM, Director of Veterinary Science at The Marine Mammal Center		Dr. Shawn Johnson is Director of Veterinary Science at The Marine Mammal Center and oversees all of the Rescue, Animal Care, Diagnostic Services, and Research activities. Dr. Johnson has more the 20 years of marine mammal veterinary medicine experience and has cared for sea otters in rehabilitations at the Alaska SeaLife Center and The Marine Mammal Center and participated in two sea otter captures trips performing anesthesia, sampling, and implant surgeries under the guidance of Dr. Mike Murray.
Cara Field, DVM, Staff Veterinarian at The Marine Mammal Center		Dr. Cara Field is the Staff Veterinarian at The Marine Mammal Center (TMMC) in Sausalito California, since October, 2014. Her primary roles include managing the care and rehabilitation of our marine mammal patients including sea otters, as well as carrying out research projects and teaching our veterinary intern and visiting veterinary residents, international vets and students among others. Sea otter specific experience includes primary medical care of

		2 captive sea otters at Audubon Nature Institute for 2.5 years, medical care of 5 captive sea otters at Georgia Aquarium for 2.5 years, primary responsibility for the rehabilitation of sea otters at TMMC, collaboration with the Monterey Bay Aquarium sea otter rehabilitation program, participation in sea otter transmitter implant surgeries, and collaborator with the US Fish and Wildlife and OWCN response groups.
Lesanna Lahner, DVM, Associate Veterinarian, Minnesota Zoo		Dr. Lahner has worked with sea otters since 2011. Over the past 7 years, Dr. Lahner has been fortunate to be mentored by Dr. Michael Murray on the topics of sea otter field surgery, medicine of captive sea otters, and husbandry related practices. During that time, Dr. Lahner has performed a variety of medical and surgical procedures on sea otters from the treatment gastrointestinal disorders to lensectomies. Dr. Lahner was honored to co-author the Sea Otter Medicine chapter in the most recent CRC Marine Mammal Medicine text.
Heather Harris, DVM, The Marine Mammal Center		Dr. Harris is a wildlife veterinarian and a board-certified specialist in veterinary preventive medicine. She completed a dual degree program at the University of California, Davis with a doctorate in veterinary medicine and a masters in wildlife epidemiology, followed by a clinical internship in marine mammal medicine and pathology at The Marine Mammal Center. Dr. Harris is on the faculty at Cal Poly San Luis Obispo in the Animal Science Department and serves as the contract veterinarian for The Marine Mammal Center at

		the San Luis Obispo Field Office, where she regularly provides emergency and critical care to sick and injured sea otters. Dr. Harris has almost 20 years of sea otter research and clinical experience under various collaborative roles associated with the Southern Sea Otter Research Alliance. She has performed all aspects of veterinary care during sea otter field captures including physical restraint, anesthesia, biological sampling, tagging, and surgical implant and explant procedures.
Raymond Wack, DVM, Senior veterinarian at the Wildlife Health Center, Veterinary Director at the Sacramento Zoo		As a senior veterinarian at the Wildlife Health Center, Dr. Wack serves as Veterinary Director at the Sacramento Zoo as well as Service Chief for Zoological Medicine at the UCDavis Veterinary Medical Teaching Hospital. Dr. Wack has 30 years of experience in clinical practice of zoological medicine including the care of sea otters and river otters of several species. Dr. Wack has previously worked with Dr. Mike Murray on sea otter transmitter implantation surgeries as well as participated in Dr. Murray's training workshops. Specific sea otter experience includes restraint, sedation, physical examination, blood draw, sample & morphometric data collection, and surgical transmitter placement surgeries. Dr. Wack is responsible for the Zoological Medicine Residency Program which is a collaboration with UCDavis SVM, Sacramento Zoo, San Diego Zoo Global and SeaWorld San Diego. Dr. Wack provides didactic and clinical training to veterinary students interested in zoological medicine. His current research interests are

		wide ranging from discovering a new amdoparvovirus in red pandas to implanting radio transmitters in giant garter snakes.
Nancy Anderson, DVM, Oiled Wildlife Network		Coordinates wildlife field care and processing activities for the Wildlife Health Center's Oiled Wildlife Care Network (OWCN). As a key manager for the OWCN's oil spill response team, lead wildlife field stabilization and evidence collection operations during oil spill response for birds, marine mammals, sea otters, sea turtles and all inland wildlife species. Collaborate with other wildlife veterinarians, biologists and wildlife rehabilitators to develop field husbandry and medical care protocols for oiled wildlife. During non-spill periods, ensure oil spill readiness by developing curriculum and leading training workshops for staff and volunteers from Member Organizations and Affiliated Agencies throughout California. Engage in research activities to ensure 'best achievable collection and care of oiled wildlife. Current research projects are focused on improving warming therapies for hypothermic seabirds and evaluating blood chemistries of debilitated seabirds at initial presentation to develop a sound scientific basis for rehydration therapy protocols. Hire and oversee field staff and volunteers. Supervise the acquisition and management of supplies and equipment necessary for field stabilization and processing operations, including mobile animal care facilities. Active in university teaching and public service activities. Since 2012, I have worked with USGS

		biologists/researchers and Dr. Mike Murray on research projects involving sea otters. Specific sea otter experience includes restraint, sedation, physical examination, blood draw, sample & morphometric data collection, and surgical transmitter placement surgeries. I was the primary author for the Field Stabilization section of "OWCN Protocols for the Care of Oil-Affected Sea Otters" and have been the Field Stabilization Group Supervisor for annual drills held at MVWCRC to train personnel and test readiness to respond in the event of a petroleum spill that affects sea otters.

ANESTHESIA

a) Provide a brief description of anesthetic procedures.

Describe

- *agent;*
- *dose (i.e., mg/kg or % if by inhalation);*
- *route of administration;*
- *expected duration of anesthesia;*
- *monitoring procedure to evaluate depth of anesthesia;*
- *maintenance and monitoring procedures to ensure normal body temperature is maintained in the animal;*
- *procedures to be employed in case of anesthetic emergency such as over-dose; and*
- *monitoring protocol to ensure animal's complete recovery from anesthesia; if by inhalation describe the equipment used and state the method of scavenging waste anesthetic gas/fumes; if injectable agent(s) are not commercially prepared and sterility guaranteed, please describe method used to assure the agent's sterility when injected;*
- *safety mechanisms to prevent personnel exposure to volatile anesthetics.*

Description: Intramuscular injections of fentanyl and midazolam are administered separately with different syringes at dose rates adjusted to the purpose of handling. Darting is not used because otters are usually in the water and the risks of drowning or 'struck and loss' are too great. We use target dose rates of 0.33 mg/kg of fentanyl and 0.11 mg/kg of midazolam for surgical procedures, and 0.22 mg/kg fentanyl and 0.07 mg/kg of midazolam for non-surgical, biological sampling procedures as recommended by Monson et al. (2001). If anesthesia is not complete after approximately 15 minutes, additional fentanyl may be given. If 2-times the initial fentanyl dose is incrementally reached, and sedation is still not complete, the antagonist is given and the animal released without further handling (this is rarely observed). In the event of excessive tremors or convulsions, additional intravenous midazolam may be administered. Inhalant agents, such as isoflurane or sevoflurane, may be used as needed should anesthetic depth be deemed inadequate by the attending veterinarian. Also, based on the best judgment of the attending veterinarian, local anesthetics such as bupivacaine may be applied when potentially painful procedures are considered in the case of animals that are immobilized with lower does or when anesthetic depth be deemed inadequate. The reversal agent Naltrexone is administered intramuscularly, at a dose equal to 2-5 times the fentanyl dose, immediately following handling. Naltrexone has a rapid onset and the initial "first response" time is typically noted within one minute. Monitoring by an experienced team member continues until reversal is complete and the animal is deemed releasable by the attending veterinarian. Body temperature is monitored by a team member throughout the procedure. In addition, sterile oxytocin (20 units/ml) may be injected intramuscularly to facilitate milk letdown in lactating females. Oxytocin, a hormone produced by the hypothalamus stimulates contraction of the smooth muscle of the mammary glands to release milk. We will only attempt to collect milk samples from females with dependent pups, no pregnant females or females without pups will be given oxytocin.

b) Identify the individual(s) performing and monitoring anesthesia. Describe that person's training and experience with regard to the administration of anesthesia for the study species.

Name and Title	Procedure Performed	Experience
Marissa Young RVT	Primary veterinary technician managing sea otter anesthetic monitoring and maintenance.	California-licensed veterinary technician and has been the primary veterinary tech for most of the field work performed in California for approximately 15 years. She is the veterinary technician at the Monterey Bay Aquarium and has experience in sea otter nursing care, including anesthesia, surgical assisting, clinical pathology, and diagnostic imaging. She has also been the primary instructor for a number of veterinary technicians and assistants from other institutions and agencies. Other technicians will participate in sea otter work, however, their involvement will be directly over seen by Ms. Young to minimize risk and maximize efficiency of the veterinary lab.

Post-operative Procedures and Care

a) Provide a brief description of all post-operative procedures and care.

Include

- *criteria to assess animal pain and the need for analgesics;*
- *type of post-operative analgesics (describe agent, dose, route of administration, frequency, duration of treatment);*
- *techniques used to ensure maintenance of normal body temperature in the animal;*
- *incision care, monitoring and time of suture removal;*
- *catheter or long term care of any chronically instrumented/implanted animals, monitoring and time of removal; and*
- *bandage/dressing monitoring and changing schedule.*

Description: After the reversal drug is administered, the attending DVM will determine that the otter is alert, responsive, and ready for release. The temperature sensitive PIT tag allows for a final temperature reading to be collected after the otter is alert, in order to ensure that body temperature is within the normal range. The otters are then released back to the original capture site as soon as possible post surgery(once fully alert), as past experience has shown that otherwise healthy otters recover much better in the natural environment than in a captive situation. The animals are monitored closely during the release process, and immediately thereafter by shore-based observers with telescopes. to ensure a quick return to normal activity. Subsequently, attempts are made to locate each otter on a daily basis for the next 2-3 years (in rare situations we may only be able to locate specific otters 2-3 times a week if otters move to a location where shore-based access is limited), with observers paying particularly close attention to the animals health and behavior for the first 4 weeks after the surgery. Any animals that appear to be in acute distress during the first 4 weeks post-release may be re-captured for examination and treatment by a veterinarian, with such decisions made on a case-by-case basis at the discretion of the PI in consultation with a veterinarian and the US Fish and Wildlife Service. Note that the close collaboration of the PI with the Monterey Bay Aquarium (MBA) and The Marine Mammal Center (TMMC) means that there is an ability to respond to an animal in distress 7 days a week, 365 days a year.

b) If post-operative analgesics will not be used, provide scientific justification.

Description: If animals are released immediately after handling, there is no opportunity to provide post-operative analgesics. In the rare case in which significant pain is anticipated post-procedure, such as an unexpected orthopedic procedure, efforts are made to work with a permit-bearing facility with the capacity to care for sea otters. The animal will be held and managed with analgesics until such time as it is deemed to be suitable for release. More specifically, if the attending veterinarian feels that the circumstances associated with the surgical procedure were such that significant post-operative analgesics are indicated, the otter will be transferred to the nearest marine mammal rehabilitation or holding facility with sea otter holding capabilities, such as Monterey Bay Aquarium, California Department of Fish & Wildlife Marine Wildlife Veterinary Care & Research Center, The Marine Mammal Center, Aquarium of the Pacific, or Sea World San Diego. Transport, holding, and care protocols will be in accordance with the facility’s standard operating procedures.

c) Describe arrangements for post-operative monitoring of animals, the individual(s) responsible for performance of monitoring, including after-hour, weekend and holiday care (if applicable).

Name and Title	Procedure Performed	Experience

Description: As described above, animals are not held for any period of time after reversal of anesthesia.

d) Describe the use of any antibiotics or other therapeutic drugs.

Include

- *agent;*
- *dose (i.e. mg/kg, IU/kg);*
- *route of administration; and*
- *frequency, duration of treatment.*

Description: Emergency drugs, when administered, are given at traditional terrestrial carnivore doses. The routine administration of drugs is limited to post-procedure antibiotics. For invasive surgery the drug, cefovecin, is administered at a dose of 8 mg/kg SQ. Pharmacokinetic studies in the sea otter indicate that therapeutic blood levels are maintained for approximately 5 days. In the cases in which non-invasive procedures, such as blood sampling or flipper tagging, are performed, a combination of procaine and benzathine penicillin are administered at doses of 50,000 U/kg IM. While not validated, it is believed that blood levels persist for 48 hrs in the sea otter.

e) If this surgical procedure induces a disease or other functional alteration, describe any anticipated adverse effects and deficiencies, monitoring protocol/schedule for animals, animals' degree of tolerance to disease/functional deficit.

Description: NA

MULTIPLE SURGERIES

Will animals be subjected to more than one (1) survival surgery? Yes ☒ No ☐

If yes, provide scientific justification and explain how surgeries are related.

Description: Time depth recorders must be retrieved in order to download recorded data. Attempts to develop externally attached TDRs for sea otters have not been successful (to-date). Based on our past experience in Alaska and California, multiple surgeries have not resulted in additional complications or significant increased risks for study animals.

SECTION IX: LITERATURE CITED

PLEASE PROVIDE COMPLETE CITATIONS OF ALL LITERATURE CITED TO SUPPORT THIS PROTOCOL.

Click or tap here to enter text.

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SECTION X: DECLARATION (ONLY COMPLETE ONE)

A) THE INFORMATION PROVIDED HEREIN IS AN ACCURATE DESCRIPTION OF MY ANIMAL CARE AND USE PROTOCOL(S). ALL PEOPLE STUDYING ANIMALS UNDER THIS PROTOCOL HAVE BEEN OR WILL BE PROPERLY TRAINED TO USE APPROPRIATE METHODS AND HAVE READ AND AGREED TO COMPLY WITH THIS PROTOCOL. ALL INDIVIDUALS WORKING UNDER THIS ASSURANCE WILL COMPLY WITH THE PROCEDURES AND METHODS OUTLINED IN THE INTERAGENCY RESEARCH ANIMAL COMMITTEE'S *U.S. GOVERNMENT PRINCIPLES FOR THE UTILIZATION AND CARE OF VERTEBRATE ANIMALS USED IN TESTING, RESEARCH, AND TRAINING*, THE ANIMAL WELFARE ACT AND ITS IMPLEMENTING REGULATIONS, AND THE PUBLIC HEALTH SERVICE POLICY EXCEPT AS OTHERWISE AUTHORIZED BY THE APPROVAL OF THIS PROTOCOL.

ALL WORK PROPOSED HEREIN IS DESIGNED TO AVOID DISCOMFORT, DISTRESS, AND PAIN TO ANIMALS TO THE EXTENT POSSIBLE; DOES NOT UNNECESSARILY DUPLICATE PREVIOUS EXPERIMENTATION; AND NON-ANIMAL ALTERNATIVES HAVE BEEN CONSIDERED.

1/30/2019

X Julie Yee

Julie Yee
Principal Investigator
Signed by: Geological Survey

B) THE INFORMATION PROVIDED HEREIN IS ACCURATE AND TRUE ACCORDING TO THE DEFINITIONS PROVIDED. I CERTIFY THAT THIS PROJECT DOES NOT ENTAIL THE STUDY OF LIVE VERTEBRATES AS DEFINED.

PRINCIPAL INVESTIGATOR

DATE

C) THE INFORMATION PROVIDED HEREIN IS ACCURATE AND TRUE ACCORDING TO THE DEFINITIONS PROVIDED. I CERTIFY THAT THIS PROJECT MEETS THE DEFINITION OF A FIELD STUDY AND DOES NOT INCLUDE PROCEDURES SUCH AS SURGERY, IMPLANTING TELEMETRY DEVICES OR ANY OTHER INVASIVE PROCEDURES, AND DOES NOT MATERIALLY ALTER THE BEHAVIOR OF THE ANIMAL/SPECIES UNDER STUDY. SHOULD ANY OF OUR METHODS SIGNIFICANTLY CHANGE, MEANING THE DEFINITIONS/REQUIREMENTS OF A FIELD STUDY AS DEFINED ABOVE ARE NO LONGER MET, I WILL SUPPLY THE ADDITIONAL INFORMATION REQUESTED IN THIS FORM AND NOTIFY ACUC PRIOR TO IMPLEMENTING THE CHANGE.

PRINCIPLE INVESTIGATOR

____

DATE

____

APHIS Category B: Animals being held for use in teaching, procedures, or research, but not yet used for those purposes.

Examples:

- *Mere holding of animals captive for observational purposes*

APHIS Category C: Procedures that produce no pain or distress, no use of pain-relieving drugs.

Capture is an essential element of most wildlife studies. For the purpose of determining the appropriate categorization of capture, the American Society of Mammalogists and the Ornithological Council analyzed existing guidance used by APHIS and the NIH Office of Animal Care to determine that most methods of capture in properly functioning devices with appropriate monitoring by field staff would constitute Category C. Free-ranging mammals captured in live traps and subsequently euthanized as part of the research study or that are taken in properly functioning kill-traps meet the standards for either USDA category C or D; the distinction between these reporting categories depends upon how the animal dies. Animals taken in live traps that show no obvious signs of pain or distress and subsequently euthanized using accepted methods that avoid inducing pain or distress and those taken in properly functioning kill traps fit the definition for reporting under USDA category C. This conclusion is consistent with example #4 in the USDA APHIS Research Facility Inspection Guide (section 14.1.10) except that death is intentional rather than unexpected. The Research Facility Inspection Guide pertains to laboratory animals rather than free-ranging wildlife, but euthanasia following a live capture that does not result in pain or distress is analogous to this example.

Mammal capture devices are designed either to hold the animal unharmed (live-traps) or to kill the animal outright upon capture. The guidelines of the American Society of Mammalogists for the use of wild mammals in research discuss appropriate methods and trap types for capturing or collecting free-ranging mammals (Gannon et al. 2007).

Barring mechanical malfunctions and with appropriate placement and trap-checking frequency, animals captured in live-traps or nets are simply held without injury until removal. Appropriate training is essential for setting capture devices and for removing animals from those devices. Pain or distress, as described in the APHIS Animal Care Resource Guide, is unlikely to result from the simple capture of free-ranging mammals using most live traps or capture techniques covered in the American Society Mammalogists, so animal usage in these instances is consistent with USDA category C.

Other example of Category C procedures in wildlife research:

- *Individual or small numbers of animals being confined and maintained in natural habitat that affords an appropriate quantity and quality of food, cover, and water*
- *The short-term and skillful restraint of animals for purposes of observation or physical examination*
- *Injection of material in amounts that will not cause adverse reactions by the following routes: intravenous, subcutaneous, intramuscular, intraperitoneal, or oral, but not intrathoracic or intracardiac*
- *Acute non-survival studies in which the animals are completely anesthetized and do not regain consciousness*
- *Approved methods of euthanasia or humane killing*
- *Short periods of food and/or water deprivation equivalent to periods of abstinence in nature.*
- *Collection of feathers, small skin punches, urine, feces, tracheal swabs, cloacal swabs*
- *Application of tagging or marking devices, except implantations into body cavities*

- *Most blood collection procedures.*
- *Administration of an anesthetic, analgesic or tranquilizing drug to an animal for restraint purposes to perform a procedure that involves no pain or distress.*

Most tissue sampling and marking techniques in the field also are consistent with USDA pain category C provided that procedures are not more invasive than peripheral blood sampling. Support for this classification is provided in the Guidelines for Preparing USDA Annual Reports and Assigning USDA Pain and Distress Categories. This document is distributed by the NIH Office of Animal Care and Use, which is the oversight office for intramural research. This guidance expressly states that Category C includes most blood and tissue collection procedures that involve no or only momentary or slight pain.

APHIS Category D: Procedures involving pain or distress for which appropriate anesthetic, analgesic, or tranquilizing drugs were used.

Examples:

- *Surgical implantation of telemetry devices or identification devices that require anesthesia or analgesia*
- *Invasive tissue sampling, such as intracardial blood draws or invasive biopsies*

APHIS Category E: Procedures that involve pain or distress for which the use of anesthetics, analgesics, or tranquilizers would have adversely affected the procedure, results, or interpretation of the results.

Examples:

- *Experimental increase of litter or clutch size that results in a statistically significant depression in growth rates, excessive loss of parental mass, or death of young or adults.*
- *Diets that cause a statistically significant reduction in growth or cause excessive loss of body mass.*

ANNUAL REPORT ON SEA OTTER (*Enhydra lutris*) RESEARCH CONDUCTED UNDER PERMIT MA672624-18 DURING 2018

20 March 2019

TO: US Fish & Wildlife Service
Division of Management Authority
Branch of Permits
4401 North Fairfax Dr., Room 212
Arlington, Virginia 22203

US Fish & Wildlife Service
Ventura Field Office
2493 Portola RD., Suite B
Ventura CA 93003

PERMITTEE: Joseph Tomoleoni, Brian Hatfield
U.S. Geological Survey – Western Ecological Research Center
Santa Cruz Field Station
2885 Mission St.
Santa Cruz, California 95060

SECTION 1: CAPTURE, MARKING, MORTALITY, AND INCIDENTAL HARASSMENT

Capture and Marking Summary All capture and marking of sea otters was done according to methods described in the most recent amended/renewed version for Permit PRT MA672624.

There were 22 sea otters captured under this permit in 2018. All 22 sea otters were captured using the diver held trap (Wilson trap) off the Monterey Peninsula. Among the 17 females captured, 1 was an aged adult, 12 were adults, 2 were subadults and 2 were pups. Four adult males and 1 male pup were also captured. Eight of the sea otters had been captured in previous years (Table 1).

All of the captured sea otters received flipper tags (either for the first time or for the replacement of lost ones) under this permit in 2018. Eight of the captured sea otters underwent surgery in 2018: 2 were implanted with radio transmitters, 5 had their TDRs removed and 1 had both its transmitter and time-depth-recorder (TDR) removed. No time-depth-recorder (TDR) implants were done in 2018. All of the independent sea otters captured for the first time received a transponder chip. A pre-molar tooth was extracted from 1 sea otter and blood samples were taken from all captured animals except for the 2 small pups (Table 2).

The 7 sea otters with functioning transmitters have been located regularly off the Monterey Peninsula (through about mid-February 2019, Table 1).

Three female-pup pairs were captured in 2018. Two of these pups were weaned successfully, and the pair without a transmitter were last seen together 24 days after capture. Weaning success of this pair could not be determined (Table 3).

Mortality of Implanted Sea Otters Eight sea otters captured under this permit and implanted/explanted with a TDR and/or a radio transmitter in previous years were recovered dead in 2018. An additional otter which had undergone surgery in October 2018 was recovered dead on 5 January 2019, 79 days after her TDR was surgically removed. Her cause of death was determined to be cardiomyopathy. One other sea otter (BRD1375) died within a year after surgery (after 317 days) and her cause of death was end lactation syndrome, possibly involving domoic acid poisoning. The 7 remaining sea otters were recovered dead between 651 days and 1948 days post-surgery. Causes of death varied but included shark bite, domoic acid poisoning, cardiomyopathy, end lactation syndrome, and one that died from research related activities (Table 4). The research-related mortality, BRD1361-16, was captured in 2016 and stranded in October 2018. The cause of death for this animal was determined to be related to the implanted instruments. This case is under review by DMA and we are conducting reviews within our research group to address this issue. Stranded Sea Otter Fact Sheets with final or preliminary necropsy findings for those that were necropsied are included as attachments to this report.

<u>Mortality of Non-Implanted Sea Otters</u> Three sea otters that were captured under our permit in previous years that had never undergone surgical procedures were recovered dead in 2018 (Table 5). Two of 3 were necropsied and the reports are attached.

<u>Incidental Harassment</u>. During wild sea otter captures using the diver held trap (Wilson trap – the only method used in 2018), other sea otters that are resting near the captured otters are incidentally harassed. When the Wilson trap hits the surface, sea otters that are not the intended targets but are within approximately 10 – 15 meters, are usually startled, immediately dive and swim away. We do not or cannot determine the exact sea otter raft size at each capture, but our observational database on tagged study animals (based on 55,000 tagged otter re-sightings collected during recent years) indicates that average resting group size in California is 4.3 otters (standard deviation =4.96, data are log-normally distributed). We made 16 capture runs using Wilson traps during which sea otters were captured in 2018, for which the 95% confidence interval for estimated mean group size (assuming 16 groups of random size) is 2.5–6.7. For each capture run we successfully capture 1.2 animals on average, so excluding captured animals our estimated number of otters incidentally harassed during all Wilson trap capture events is 49, with 95% confidence interval 21 - 88.

SECTION 2: RESEARCH GOALS AND PROGRESS MADE IN 2018

Progress Made in Meeting Objectives

Outstanding progress was made on the Monterey Peninsula Predator Diversity project, our only tracking study in 2018. The Monterey project was initiated in June 2016 as part of a larger NSF-funded study to examine the effects of predator diversity on the stability and resilience of kelp forest ecosystems in the face of an ongoing epidemic that has caused coast-wide losses of key sea star species. Southern sea otters were tagged and monitored in order to examine their ability to compensate for the declines in sea stars, another important predator of invertebrates in kelp forest ecosystems. Data collection on the Monterey project is slated to continue at least through summer of 2019, and possibly longer if NSF grants an extension for this project. In 2018 our tracking efforts were very robust, with daily or near daily efforts to locate each study animal. The total tracking effort includes time dedicated to the collection of foraging data as well as other more general objectives relevant to sea otter biology and conservation (see Annual Permit Report for 2017). During 2018 a total of 5,251 resights were collected and entered by field personnel in the Monterey Peninsula study area. Since the beginning of the project, 14,874 resights have been made on our study animals. A total of 8 radio-implanted and 3 non-instrumented sea otters were recovered dead this year, all from the Monterey Peninsula study. This brings the total number of confirmed deceased study animals to 18 since the start of the Monterey Peninsula study. Cause of death and mortality information for all 11 deceased sea otters is referenced earlier in this report (see the Morality of Implanted (and Non-Implanted) Sea Otters sections and Tables 4 and 5).

Since the beginning of the Monterey Peninsula study in June 2016, a total of 41 pups have been born to study animals. Of those 41 pups, 26 have been weaned successfully while only 8 pups did not survive until weaning. As of December 31, 2018, 7 pups had not yet reached weaning age, and thus, were still dependent on their mothers.

We have made excellent progress in collecting foraging data since the beginning of the Monterey Peninsula study, and that productivity has continued through 2018. To date, a total of 24,330 individual foraging dives and 1,422 distinct foraging bouts have been recorded during this study. Of those totals, 7,932 dives (33% of total) and 473 bouts (33% of total) were recorded in 2018. Mussels and sea urchins continue to dominate the diet in the sea otters of the Monterey Peninsula, together accounting for about 54% of the total prey items consumed. Crabs, snails, and abalone round out the mostly commonly consumed prey species, each accounting for more than 5% of the sea otter diet (Figure 1).

On March 19, 2018, sea otter captures were conducted in Monterey. These captures served a dual purpose: (1) to add new otters to the study, correcting our decreased sample size due to relatively high natural mortality in the previous year and (2) to recapture previously tagged study animals that had chewed off one or both flipper tags, so that new tags could be placed on the otters and facilitate their monitoring throughout the study. Of the 5 captured otters in March 2018, 2 were implanted with VHF radio transmitters and were added to the long term Monterey study. The remaining 3 otters all received flipper tags so that they could be identified post-capture and resighted opportunistically, but since they cannot be located via VHF radio telemetry, they are not considered to be reliable study animals for regular data collection. No TDR's were implanted during the March captures. From October 15-19, 2018, five days of sea otter captures were conducted, with the primary purpose of recapturing study animals and recovering their TDR's. These recaptures were highly successful, with a total of 17 sea otters captured and 6 TDR's removed/recovered, providing a wealth of dive and body temperature data from those 6 animals. The 11 sea otters captured that didn't have TDRs removed were either (a) too pregnant to have surgery conducted, (b) targeted recaptures of animals that were missing one or both flipper tags, in order to replace the flipper tags and facilitate better monitoring or (c) non-target animals captured while attempting to capture an animal that fell into category (a) or (b). In the latter case, these non-target animals were bio-sampled as part of our study, and flipper-tagged to allow for opportunistic data collection, but did not undergo surgery and were not implanted with instruments. In fact, no new instruments (VHF transmitter or TDR) were deployed during the October recaptures.

Future Research & Collaborations

In 2019 we anticipate the continuation of data collection on the Monterey Peninsula NSF study with daily data collection through the end of the study, which is set to terminate in summer of 2019 but could be extended pending additional funding. At this time there are no plans for another large scale capture effort to initiate any new studies in 2019; however, there will be several smaller scale (1-2 day) re-capture efforts in Monterey that aim to both (1) replace missing tags with new tags and (2) recover previously implanted time-depth recorders.

As previously mentioned in several past permit reports, progress continues to be made on new tagging technologies for the future of sea otter monitoring. Multiple avenues are being pursued, but the one that holds the most promise involves a collaboration between USGS WERC researchers (both sea otter and bird biologists who have a mutual interest in miniaturized tags that employ new technologies) and NASA Ames researchers that have the engineering expertise to design new tags. We are very encouraged by the progress made so far, and are hoping to have a prototype "smart" flipper tag ready for deployment on captive sea otters at the Monterey Bay Aquarium (under their existing permit) in early 2019. The new flipper tags will have the ability to obtain GPS locations, which is something that no sea otter tag has ever been able to do. The ability to obtain many GPS locations of a sea otter without physically resighting the animal, and have those data offloaded to a base-station, will create many new opportunities for research projects that are interested in fine scale geospatial data without requiring a large workforce of biologists and volunteers to physically locate each study animal every day. Since the smart flipper tag is external, successful deployment of this tag may provide a method for obtaining geospatial data without surgically implanting instruments in sea otters. Further communication with the permit office will occur once we deem the tags ready for field deployment on wild sea otters to ensure that all necessary permissions have been obtained. It should be noted, however, that the implantation of subcutaneous transmitter tags is already covered in both our Federal permit and our existing ACUC permit with USGS, and the development of a smart flipper tag is even less invasive (and thereby less risky) than a subcutaneous tag, which was already less invasive than our current intra-abdominal implants.

In 2018, with support from the U. S. Navy, we continued our on-going sea otter work at San Nicolas Island, performing sea otter surveys 4 times per year. This robust research effort also includes the collection of foraging data on untagged sea otters at San Nicolas Island, the first effort to examine sea otter diet and resource abundance at this location in over a decade. The research plan for this study consists of 3 tiers of monitoring. For all of 2018, and at present time in 2019, we remain at the Tier 1 level, which mandates that we conduct 4 surveys per year and collect as much foraging data as possible during these field trips. If, during the course of our study we discover that: (1) a single dead, moribund, or stranded sea otter is found with injuries consistent with impacts from Navy activities or (2) the sea otter population at San Nicolas Island decreases by more than 10% from the average trend of the preceding 3-year period for at least 2 consecutive years or (3) the total population of sea otters at San Nicolas Island drops below 75 individuals, the level of research would be elevated to Tier 2 or Tier 3. Tier 2 requires additional operational monitoring for any new military readiness activities with the potential to impact sea otters or their habitat. If conditions exist that require the research to be elevated to Tier 3, this would involve advanced monitoring of the sea otter population, and would require the capture, tagging, and instrumentation of approximately 25 sea otters at San Nicolas Island, with intensive and regular monitoring of the tagged animals post-release.

In 2019, we will be involved in a new research project with collaborators from Sonoma State University (Dr. Brent Hughes), the National Park Service, the University of Virginia, the University of California Santa Barbara, and others, to assess the habitat quality and prey abundance of Drakes Estero estuary at Point Reyes National Seashore, in order to determine the suitability of this estuary as future sea otter habitat. The estuary currently lies outside the range of the southern sea otter, but could one day serve as a major area of sea otter occupation, either by natural range expansion or release of rehabilitated animals. As sea otters continue to expand their range in California, baseline data from areas that presently have no sea otters will be of high value in both predicting areas of high sea otter use, but also in monitoring ecosystem change as sea otters become established. In 2019 this project does not plan to capture or perform any research directly on sea otters, but instead will be assessing habitat and prey base via a variety of established methodologies.

Our sea otter research program has a long history of successful collaboration with our many research partners, and we intend to continue this mutually beneficial arrangement with other sea otter researchers. The on-going Monterey Peninsula study involves our partners at the Monterey Bay Aquarium, the University of California Santa Cruz, and the California Department of Fish & Wildlife. At San Nicolas Island we continue to collaborate with all of the above agencies and institutions, but also with the U.S. Navy and USFWS. In 2019, we will continue to work closely with our USGS colleagues in Alaska, alongside the National Park Service, to perform ecosystem monitoring studies designed to assess the long-term impacts of sea otters on prey species and overall community structure in areas like Glacier Bay, AK. We also plan to participate a joint USGS-USFWS research effort to capture and implant sea otters in Katchemak Bay, Alaska (under the Alaska USGS permit); a study that seeks to determine the efficacy of new "life history tags" in sea otters. We are also excited for new collaborations with Sonoma State University (previously mentioned Drakes-Estero study) and the University of San Francisco (Dr. Nicole Thometz), where we are currently developing a study that looks at the foraging ecology of southern sea otters at the northern edge of their range, a historically understudied population.

Our current permit MA672624-18 expired in September 2018, however our renewal application was submitted more than 30 days in advance of the date of expiry, and USFWS granted us permission to continue our research activities under our expired permit while our application for renewal is being reviewed. As our permit renewal application is still under review, we are continuing to operate under our old permit. However, due to the occurrence of a research-related mortality in October, we are currently not deploying any new surgically implanted instruments in sea otters, and we are actively seeking a solution that will minimize the likelihood of a similar such mortality occurring in the future. Once an acceptable solution is agreed upon, we intend to present the solution to the USFWS DMA for review and approval.

Individuals permitted to handle otters:

M. Tim Tinker

Jack Ames

Nancy Anderson

James Bodkin

Dan Costa

George Esslinger

James Estes

Christine Fiorello

Heather Harris

Mike Harris

Brian Hatfield

Brent Hughes

David Jessup

Christine Kreuder-Johnson

Michael Kenner

Lesanna Lahner

Melissa Miller

Daniel Monson

Michael Murray

Seth Newsome

Michelle Staedler

Joseph Tomoleoni

Raymund Wack

Benjamin Weitzman

Terrie Williams

Colleen Young

Additional Tracking Personnel not listed on permit:

Nicole LaRoche

Gena Bentall

Teri Nicholson

Sarah Espinosa

Sarah Chinn

Zach Randell

Jessica Fujii

Sophia Lyon

Table 1. Summary of sea otters captured in California under Permit MA672624 in 2018.

OTTER BRD NO.	CAPTURE DATE	LOCATION	SEX	AGE	WT (kg)	LENGTH (cm)	TDR	FUNCTIONING TRANSMITTER?	STATUS (AS OF MID-FEB 2019)
1378-18	19-Mar-18	Monterey Peninsula	F	A	15.6	113.5	NONE	YES	Frequently resighted
1379-18	19-Mar-18	Monterey Peninsula	F	A	17.0	115.3	NONE	NONE	Not seen since tagged
1380-18	19-Mar-18	Monterey Peninsula	F	A	20.3	117.5	NONE	NONE	Last seen 11/15/18
1381-18	19-Mar-18	Monterey Peninsula	F	SA	18.0	114.5	NONE	YES	Frequently resighted
1382-18	19-Mar-18	Monterey Peninsula	F	A	17.8	118.0	NONE	NONE	Frequently resighted
1181-12-3	15-Oct-18	Monterey Peninsula	F	A	21.0	120.9	REMOVED	YES	Frequently resighted
1348-16-2	15-Oct-18	Monterey Peninsula	F	AA	23.4	118.6	REMOVED	REMOVED	Frequently resighted
1373-16-2	15-Oct-18	Monterey Peninsula	M	A	34.8	135.7	REMOVED	YES	Frequently resighted
1383-18	15-Oct-18	Monterey Peninsula	F	SA	15.7	108.9	NONE	NONE	Last seen 1/24/18
1205-12-2	16-Oct-18	Monterey Peninsula	F	A	22.5	122.0	NONE	NONE	Last seen 11/9/18
1384-18	16-Oct-18	Monterey Peninsula	M	A	29.5	120.6	NONE	NONE	Frequently resighted

OTTERN BRD NO.	CAPTURE DATE	LOCATION	SEX	AGE	WT (kg)	LENGTH (cm)	TDR	FUNCTIONING TRANSMITTER?	STATUS (AS OF MID-FEB 2019)
1385-18	16-Oct-18	Monterey Peninsula	F	A	23.3	122.6	NONE	NONE	Frequently resighted
1386-18	16-Oct-18	Monterey Peninsula	M	P	-	-	NONE	NONE	Last seen 11/9/18
1346-15-2	17-Oct-18	Monterey Peninsula	F	A	22.0	117.0	REMOVED	YES	Frequently resighted
1359-16-2	17-Oct-18	Monterey Peninsula	F	A	20.7	116.2	REMOVED	YES	Frequently resighted
1387-18	17-Oct-18	Monterey Peninsula	F	P	4.2	-	NONE	NONE	Last seen 2/22/19
1388-18	17-Oct-18	Monterey Peninsula	F	A	22.2	118.0	NONE	NONE	Frequently resighted
1389-18	17-Oct-18	Monterey Peninsula	M	A	29.6	127.5	NONE	NONE	Frequently resighted
1351-16-2	18-Oct-18	Monterey Peninsula	F	A	21.0	114.9	REMOVED	N/A	Died 1/5/2019
1390-18	18-Oct-18	Monterey Peninsula	F	P	11.8	95.6	NONE	NONE	Last seen 11/08/18
1391-18	18-Oct-18	Monterey Peninsula	M	A	29.7	130.1	NONE	NONE	Last seen 11/6/18
1350-16-2	19-Oct-18	Monterey Peninsula	F	A	24.4	124.0	HAS EXISTING	YES	Frequently resighted

Table 2. Marks applied to and samples taken from sea otters captured in California under Permit MA672624 in 2017.

							SAMPLES COLLECTED										
													SWABS/SMEARS				
OTTER BRD NO.	CAPTURE DATE	R TAG COLOR	L TAG COLOR	TRANSPONDER	RADIO TRANSMITTER	TDR IMPLANT	TOOTH	BLOOD	TISSUE PLUG	LIVER BIOPSY	HAIR	WHISKER	FAT	BUCCAL	ANAL	NASAL	SALIVA
1378-18	19-Mar-18	WH	LB	985141000930006	167.780	NONE	UR	Y	Y	N	Y	Y	Y	Y	N	Y	N
1379-18	19-Mar-18	RE	WH	985141000929851	NONE	NONE	N	Y	Y	N	Y	Y	N	Y	N	Y	N
1380-18	19-Mar-18	LB	LG	985141000929912	NONE	NONE	N	Y	Y	N	Y	Y	N	Y	N	Y	N
1381-18	19-Mar-18	PI	YE	985141000929924	167.255	NONE	N	Y	Y	N	Y	Y	Y	Y	N	Y	N
1382-18	19-Mar-18	WH	RB	985141000929859	NONE	NONE	N	Y	Y	N	Y	Y	N	Y	N	Y	N
1181-12-3	15-Oct-18	PU	SI	HAS EXISTING	HAS EXISTING	REMOVED	N	Y	N	N	Y	Y	N	Y	Y	Y	N
1205-12-2	16-Oct-18	YE	OR	HAS EXISTING	NONE	NONE	N	Y	N	N	Y	Y	N	Y	Y	Y	N
1346-15-2	17-Oct-18	TQ	OR	HAS EXISTING	HAS EXISTING	REMOVED	N	Y	N	N	Y	Y	N	N	Y	Y	N
1348-16-2	15-Oct-18	TQ	RE	HAS EXISTING	REMOVED	REMOVED	N	Y	N	N	Y	Y	N	Y	Y	Y	N
1350-16-2	19-Oct-18	TQ	RB	HAS EXISTING	HAS EXISTING	SAME	N	Y	N	N	Y	Y	N	Y	N	Y	N
1351-16-2	18-Oct-18	LB	CH	HAS EXISTING	HAS EXISTING	REMOVED	N	Y	N	N	Y	Y	N	N	Y	Y	N
1359-16-2	17-Oct-18	TQ	WH	HAS EXISTING	HAS EXISTING	REMOVED	N	Y	N	N	Y	Y	N	Y	Y	Y	N
1373-16-2	15-Oct-18	TQ	OR	HAS EXISTING	HAS EXISTING	REMOVED	N	Y	N	N	Y	Y	N	Y	Y	Y	N
1384-18	16-Oct-18	TQ	YE	985141001043641	NONE	NONE	N	Y	N	N	Y	Y	N	Y	Y	Y	N
1385-18	16-Oct-18	YE	LG	985141001043638	NONE	NONE	N	Y	N	N	Y	Y	N	Y	Y	Y	N
1386-18	16-Oct-18	none	none	NA	NONE	NONE	N	N	N	N	N	N	N	N	N	N	N
1387-18	17-Oct-18	none	none	985141001304012	NONE	NONE	N	N	N	N	N	N	N	N	N	N	N

							SAMPLES COLLECTED										
													SWABS/SMEARS				
OTTER BRD NO.	**CAPTURE DATE**	**R TAG COLOR**	**L TAG COLOR**	**TRANSPONDER**	**RADIO TRANSMITTER**	**TDR IMPLANT**	**TOOTH**	**BLOOD**	**TISSUE PLUG**	**LIVER BIOPSY**	**HAIR**	**WHISKER**	**FAT**	**BUCCAL**	**ANAL**	**NASAL**	**SALIVA**
1388-18	17-Oct-18	RB	RE	985141001304010	NONE	NONE	N	Y	Y	N	Y	Y	N	Y	Y	Y	N
1389-18	17-Oct-18	YE	CH	985141001304006	NONE	NONE	N	Y	Y	N	Y	Y	N	Y	N	Y	N
1390-18	18-Oct-18	LB	GO	NA	NONE	NONE	N	Y	Y	N	Y	N	N	Y	N	N	N
1391-18	18-Oct-18	TQ	CH	985141001304013	NONE	NONE	N	Y	Y	N	Y	Y	N	Y	Y	Y	N
1383-18	15-Oct-18	YE	SI	985141001043637	NONE	NONE	N	Y	N	N	Y	Y	N	Y	Y	Y	N

Table 3. Summary of Mother/Pup pairs captured in California under Permit MA672624 in 2018.

MOM/ PUP	OTTER BRD NO.	SEX	AGE	WT (kg)	LENGTH (cm)	FLIPPER TAGGED	PIT TAGGED	TRANSMITTER	TDR	CAP/ RELEASE DATE	LAST SEEN W/ PUP	FIRST SEEN W/O PUP	SUCCESSFULLY WEANED	COMMENTS
MOM	1205-12	F	AD	22.5	122	Y	Y	N	N	16-Oct-18	9-Nov-18	n/a	Unknown	Not seen after 9 Nov 2018
PUP	1386-18	M	P	5.9	-	N	N	N	N	16-Oct-18				Not seen after 9 Nov 2018
MOM	1359-16	F	AD	20.7	116.2	Y	Y	PREVIOUSLY	REMOVED	17-Oct-18	22-Feb-19	24-Feb-19		Mom still seen regularly
PUP	1387-18	F	P	4.2		N	N	N	N	17-Oct-18			Yes	not tagged
MOM	1351-16	F	AD	21	115	Y	Y	PREVIOUSLY	REMOVED	18-Oct-18	30-Oct-18	1-Nov-18		Mom died Jan 2019
PUP	1390-18	F	P	11.8	95.6	Y	N	N	N	18-Oct-18			Yes	Last seen on own 8 Nov 2018

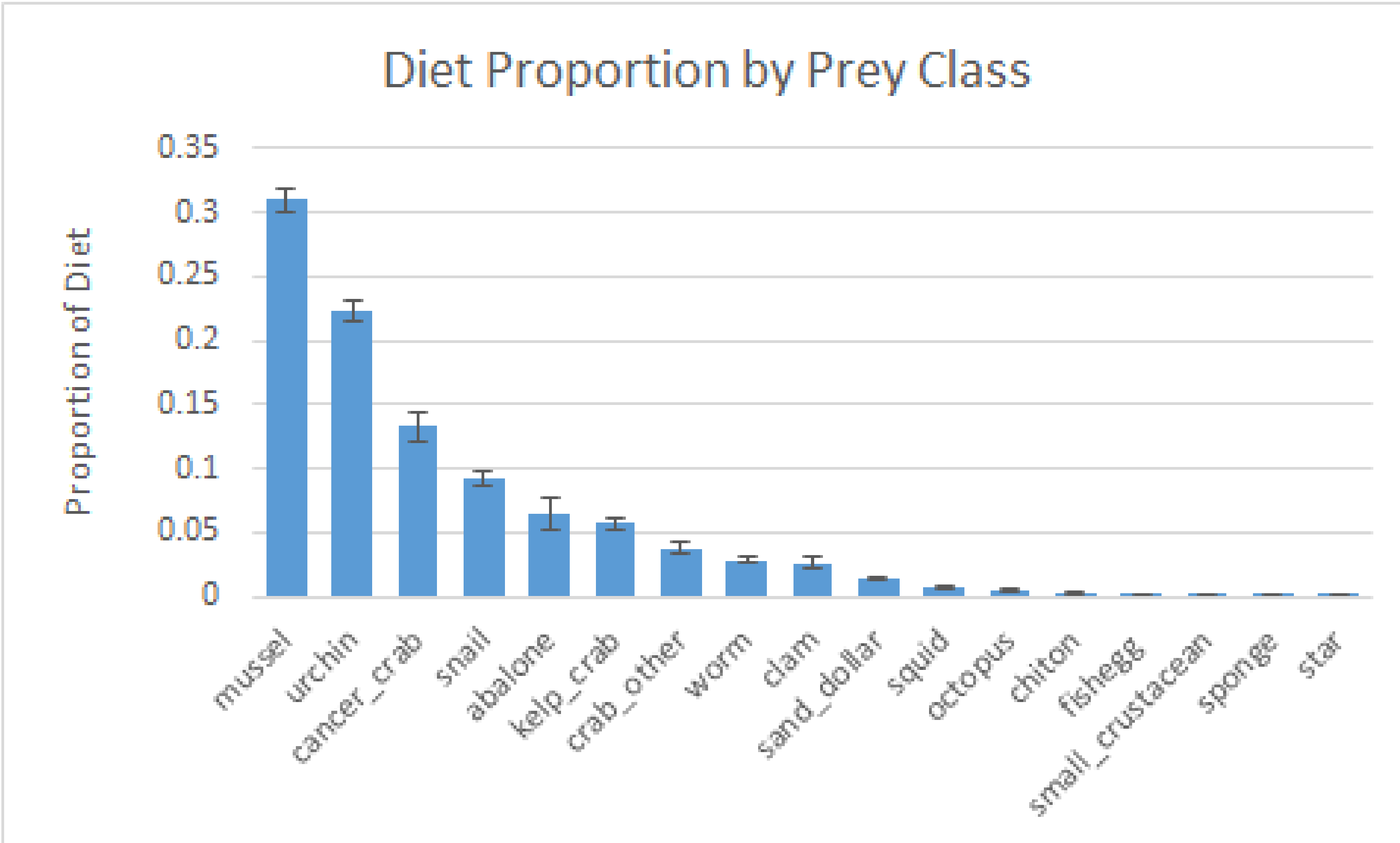
Table 4. Surgically implanted sea otters captured under Permit PRT MA672624 that died in 2018. Sea otters listed by recovery date.

Otter BRD No.	SO#	Age/Sex	Date of Last Surgery	Date Recovered	No. Days Since Last Surgery	Condition	Capture Wt. (kg)	Stranding Wt. (kg)	Primary Cause(s) of Stranding
1213-12	8734-18	AD/M	2-Oct-12	1-Feb-18	1948	FRESH	33.3		SHARK BITE
1307-13	8735-18	AD/F	19-Sep-13	1-Feb-18	1596	MOD	19		UNKNOWN
1330-14	8744-18	AD/F	23-Sep-14	10-Feb-18	1236	FRESH	18.5	17.7	DOMOIC ACID
1358-16	8770-18	AD/M	2-Jun-16	5-Mar-18	641	ADV	28.3	-	UNKNOWN WITH TRAUMA
1268-13	8962-18	AD/M	11-Mar-13	4-Jul-18	1941	ADV	32.8	-	DOMOIC ACID PROBABLE
1229-12	9004-18	AD/F	5-Oct-12	31-Jul-18	2125	ADV	19.9	-	UNKNOWN
1375-17	9018-18	AD/F	27-Sep-17	10-Aug-18	317	ADV	18.8	-	END LACTATION SYNDROME +- DOMOIC ACID
1361-16	9071-18	AD/F	3-Jun-16	4-Oct-18	853	ADV	14.4	23.5	RESEARCH RELATED
1351-16-2	9140-19	AD/F	18-Oct-18	5-Jan-19	79	FRESH			CARDIOMYOPATHY

Table 5. Non-implanted sea otters captured under Permit PRT MA672624 that died in 2018. Sea otters listed by recovery date

Otter BRD No.	SO#	Age/Sex	Date Last Captured	Date Recovered	No. Days Since Last Capture	Condition	Capture Wt. (kg)	Stranding Wt. (kg)	Primary Cause(s) of Stranding
1133-09	8776-18	AA/F	24-Aug-09	8-Mar-18	3118	FRESH	17.9	18.4	CARDIOMYOPATHY
1111-09-5	8923-18	AA/F	26-Sep-17	7-Jun-18	254	FRESH	22.6	-	UNKNOWN, NOT RECOVERED
1380-18	9103-18	AD/F	19-Mar-18	3-Nov-18	229	FRESH	20.3		DOMOIC ACID

Figure 1. Sea otter diet composition by prey type in the Monterey Peninsula study, 2016-2018.



CDFW SEA OTTER NECROPSY REPORT

California Department of Fish and Wildlife
Office of Spill Prevention and Response
Marine Wildlife Veterinary Care and Research Center
151 McAllister Way
Santa Cruz, CA 95060
(831) 469-1719

Sea Otter:	8734-18
UCD PATH:	18S0078
MWVCRC Necrops	18-0020
Report Date:	2/7/2018
Report Status:	Gross

CASE PROFILE

DFG/BRD#:	1213	**Report By:**	Melissa Miller
UON#:	N-1491-12-S	**Necropsy By:**	Miller, Dodd, Greenwald, Reed
MBA#:		**Necropsy Date:**	2/2/2018
Date Found:	2/1/2018	**Condition:**	Fresh
Condition Found:	Fresh	**Sex:**	Male
Live Strand:	No	**Age Class:**	Adult
Euthanized:	No	**Estimated Age:**	4-6 MM
Date Died:		**Location:**	Morro Strand just south of Hwy 41
Total Length (cm):	132	**County:**	San Luis Obispo
Weight (kg):	22.3	**ATOS:**	823
Nutritional State:	Emaciated	**DSOFS COD:**	5
SQ Fat:	Scant	**Histopathology:**	Full
Food in Gut:	Little		

MORTALITY DATABASE CODING

Mortality Code:	TS
Primary COD:	Subacute shark bite, pres.
Sequela 1:	SQ abscess
Sequela 2:	Regional bacterial spread
Sequela 3:	Anemia/ hypovolemia
Secondary COD:	Gastric erosions and melena
Sequela 1:	Anemia/ hypovolemia
Tertiary COD:	Enterocolitis
Quaternary COD:	Acanthocephalan peritonitis, mild

CASE BACKGROUND

1213-12, N-1491-12-S captured 10/2/2012 of Cayucos with Dip Net. Male subadult. Implanted with TDR (1290161) /VHF (164.462), tagged Right: LG 4/5 mba049, Left: PU 1/2 mba061, PIT: SLO2012009 in right inguinal area.

GROSS DIAGNOSES

1. Shark bite, presumptive, subacute/ chronic, severe, characterized by:
   -Multifocal skin and soft tissue lacerations with perilesional granulation tissue and early fibrous connective tissue (most severe over right dorsal hemithorax)

1a) SQ abscess, cellulitis and myositis severe, subacute to chronic: Right dorsal hemithorax: Focal large SQ abscess with marked tissue cavitation, focally extensive encapsulation and purulent myositis

1b) Regional bacterial spread: R axillary and sublumbar LNs: Solid, tan (Reactive) (remainder of lymph nodes mildly/ moderately enlarged, soft and wet-looking due to acute drainage reaction)

1c) Anemia and hypovolemia, moderate

2. Gastric erosions and melena, severe

2a) Anemia and hypovolemia, moderate

3. Possible segmental, severe bacterial enteritis, characterized by:
   -Marked intestinal mural thickening and serosal pleating

4. Acanthocephalan peritonitis, mild (Related to #3?)
   -Mild intestinal Profilicollis

5. Intestinal trematodiasis, severe (Related to #3?)

6. Emaciation

INCIDENTAL FINDINGS:

1. TDR entrapped in omental bursa, not boloed

2. VHF free-floating

3. Surgical scar unremarkable

4. Presumptive viral plaque, ventral midline of tongue

5. Mild intestinal Corynosoma

6. Rectum contained trace mussel shell and small crab carapace fragments

7. Right pinna: Patchy erosions/ alopecia (DDX dermatitis, fight trauma, stranding-associated trauma)

   -Multifocal small white nose wounds, planum nasale

8. Slight congenital umbilical defect (Not open to the peritoneum)

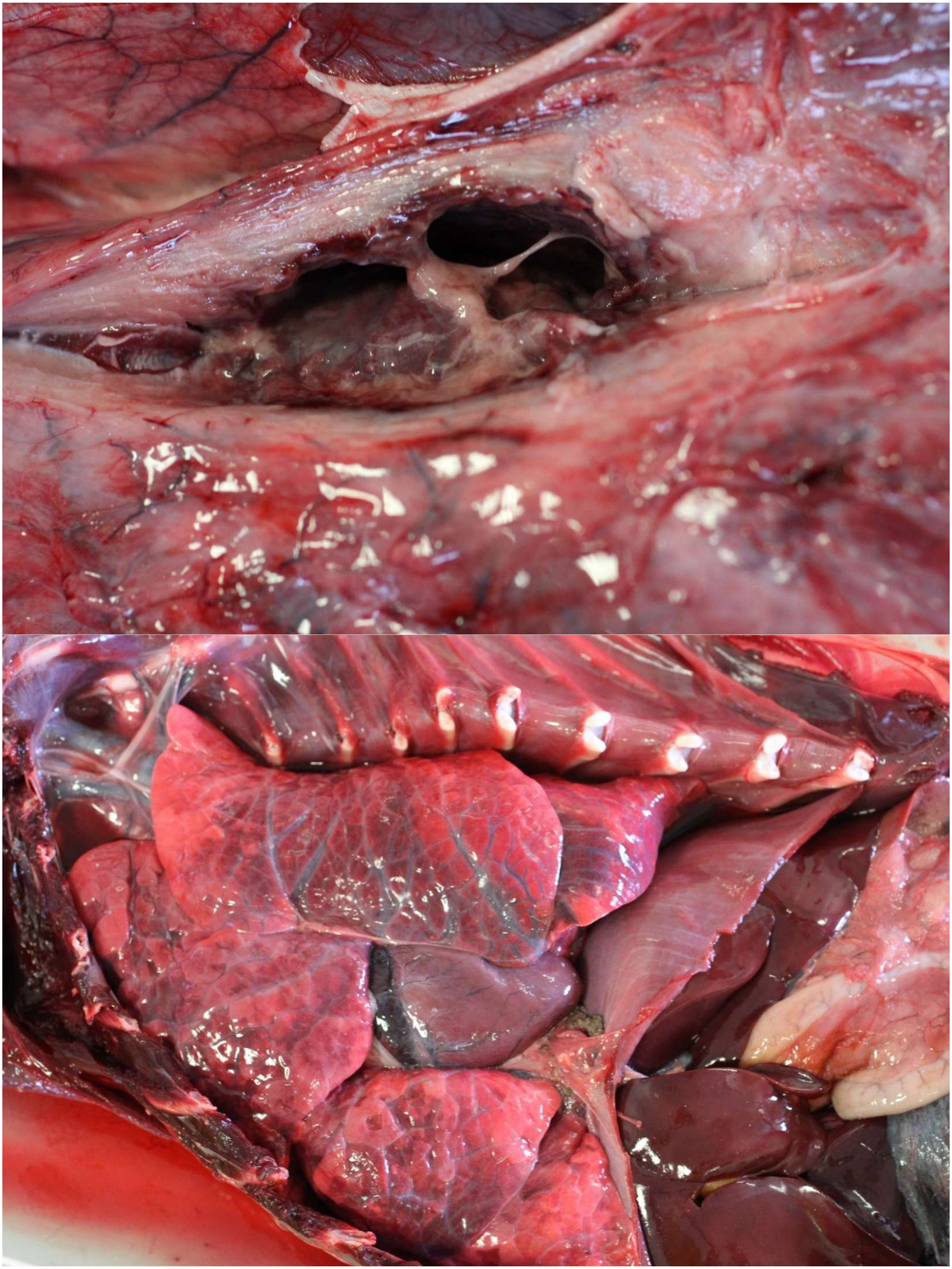
GROSS SUMMARY

Findings from gross necropsy are consistent with shark bite as the cause of death, although no scratches or fragments of shark teeth were found. Although it is common to observe differential healing of shark bite lesions on sea otters in relation to anatomic location of wounds, the frequency of wound immersion in seawater, wound characteristics, and extent of secondary infection, the adjacent wounds were so widely disparate in the extent of tissue reaction in this case that the possibility of two discrete episodes of shark bite was considered at first, but then discarded in favor of a single shark bite event, with secondary mild postmortem scavenging of tissue through partially healed wounds on the left caudodorsal chest wall. The oldest-appearing wounds were centered on the right dorsal hemithorax: Extensive SQ and intramuscular abscesses, cellulitis and myositis over the right thoracolumbar region were associated with two fully closed and well-healed skin perforations that were neither visible nor palpable on the external skin surface, and were marked by almost fully healed scars on the corresponding dermal surface. These lesions were associated with marked, perilesional tissue granulation and fibroplasia, suggestive of subacute to chronic shark bite wounds. The portion of the abscess directly underlying the healed lacerations was well encapsulated by admixed granulation tissue and FCT. Marked tissue cavitation and expansion of pus into lumbar epaxial muscle distal to the wounds was noted, along with regional matting and flattening of the pelage, likely due to chronic leakage of pus and serum. Abundant light green pus could be expressed from the cavitated areas.

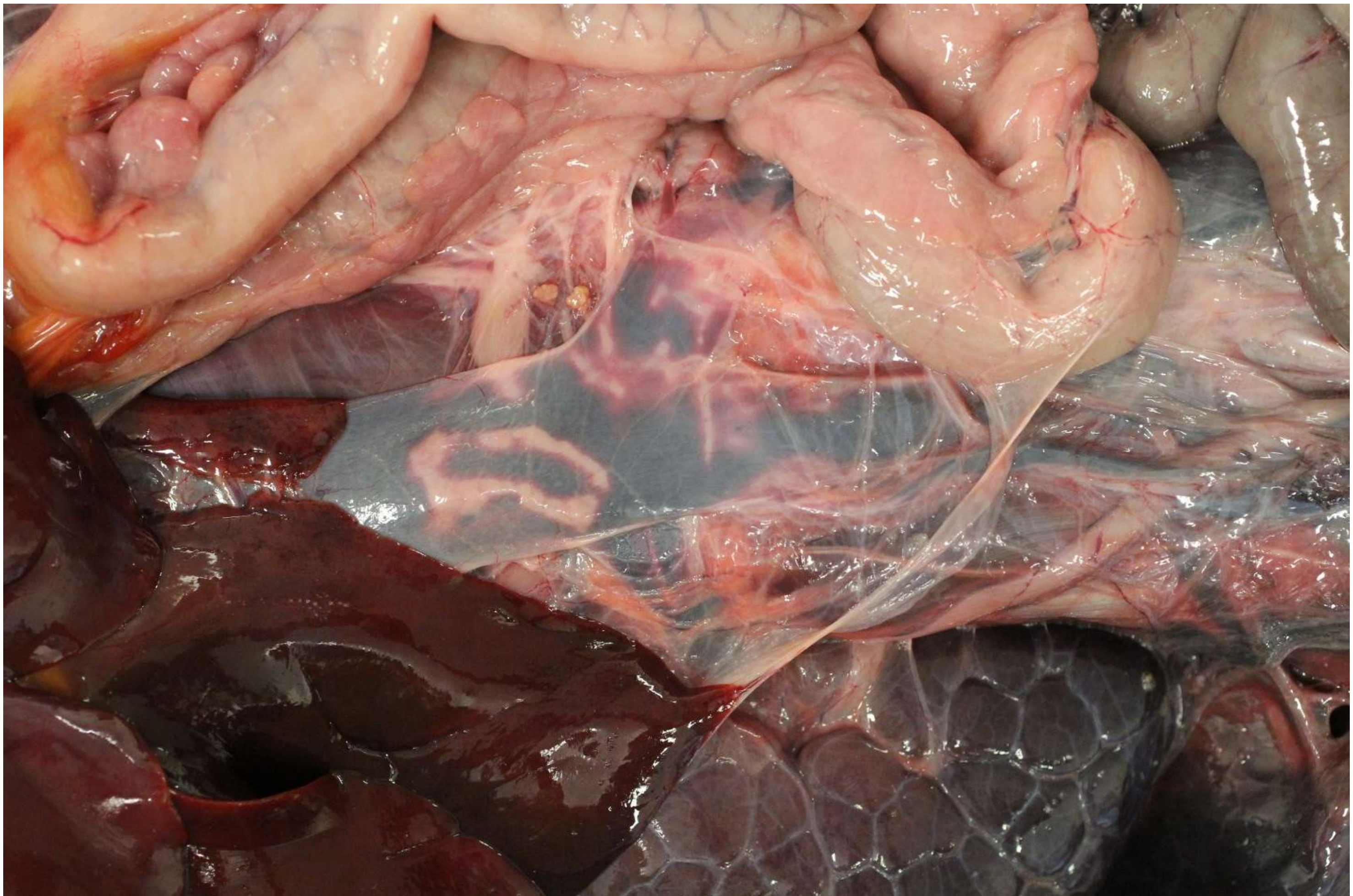
The two, more “acute-looking” full-thickness skin and soft tissue lacerations on the left caudodorsal hemithorax, were likely artificially widened and disrupted postmortem due to scavenging, resulting in postmortem penetration of the chest cavity. This assessment is based on mild postmortem scavenging of the intercoastal muscles in this area, and absence of any apparent perilesional tissue response inside the thorax where sand, seawater and sparse amphipods had accumulated.

Also noted were severe gastric erosions and melena, mild acanth. peritonitis, severe intestinal trematodiasis and marked intestinal mural thickening suggestive of concurrent enteritis. The VHF was free-floating and the TDR was entrapped in the omental bursa. The surgical scar was unremarkable.

Top & Bottom: Dorsal thoracolumbar region showing two wounds over the left hemithorax expanded by mild PM scavenging. Additional skin lacerations along the right hemithorax were closed and almost fully healed. Note regional flattening of pelage due to leakage of pus and serum from the wounds. Bottom: Same area with skin removed, making the PM scavenging more easily visible. Pus pockets & cavitation from the right thoracic wall wound extended from the left to the right tissue margins.



Top: Extensive encapsulation around abscess on right hemithorax   Bottom: The left caudal chest was artifactually opened to the environment postmortem, with no apparent pleural reaction to influx of sand, seawater and amphipods. Incomplete lung collapse due to sand in bronchi.



Top: Collapsed portal vein (hypovolemia) Bottom: Severe gastric erosions & melena

Both: Intestinal mural thickening, serosal pleating, mild acanthocephalan peritonitis, free-floating VHF

TDR entrapped in omentum

CDFW SEA OTTER NECROPSY REPORT

California Department of Fish and Wildlife
Office of Spill Prevention and Response
Marine Wildlife Veterinary Care and Research Center
151 McAllister Way
Santa Cruz, CA 95060
(831) 469-1719

Sea Otter:	8735-18
UCD PATH:	18S0096
MWVCRC Necropsy:	18-0021
Report Date:	2/7/2018
Report Status:	Gross

CASE PROFILE

DFG/BRD#:	1307	**Report By:**	Melissa Miller
UON#:	N-1584-13-S	**Necropsy By:**	Miller, Greenwald
MBA#:		**Necropsy Date:**	2/2/2018
Date Found:	2/1/2018	**Condition:**	Adv Decomp
Condition Found:	Adv Decomp	**Sex:**	Female
Live Strand:	No	**Age Class:**	Adult
Euthanized:	No	**Estimated Age:**	5-7 Miller
Date Died:		**Location:**	Salinas River Wildlife Refuge, S of plover sign #22
Total Length (cm):	124	**County:**	Monterey
Weight (kg):	-15.1	**ATOS:**	336
Nutritional State:	Good	**DSOFS COD:**	1
SQ Fat:	Moderate	**Histopathology:**	Partial
Food in Gut:	None		

MORTALITY DATABASE CODING
Mortality Code: 1
Primary COD: Unknown

CASE BACKGROUND

Captured 9/19/2013 at Seal Bend West in Elkhorn Slough as a subadult female 19 kg, 121 cm, age estimate 3 years, VHF 173.496, no TDR.

GROSS DIAGNOSES

Advanced decomposition
Very sandy pelage

1 Unknown cause of death

2 Cannot completely R/O perimortem trauma (unknown type), char. by focal hole over right scapula with extensive postmortem scavenging (DDx PM wear through pelage due to continuous sand abrasion and autolysis, followed by scavenging)

3 Cannot completely R/O perimortem gastric bloat/gastritis?, char. by:
-Stomach markedly dilated, with diffusely black-red gastric serosa and mucosa (No food in GI tract)

-No gastric or splenic displacement

4 Focal area of triangular-shaped hemorrhage on inner surface of aortic trunk (R/O perimortem scavenge wound?)

5 Reproductive stage: Late stage 3 or early stage 4 female (possible pre-wean of pup?), char by:
-Small, symmetrical uterine horns, palpable placental band right horn
-Large (1 cm thick) pink mammary glands, no lactation
-Cervix small and closed, no cervical bruising, no obvious CLs or follicles on either ovary (very decomposed though)
-Vulva not swollen
-No fresh nose wounds

6 VHF transmitter entrapped in omentum and boloed, with firm, tightly twisted omental stalk, no TDR, Sx scar unremarkable

INCIDENTAL:
Mild intestinal Corynosoma

GROSS SUMMARY

Unfortunately due to advanced autolysis, the cause of death could not be determined.

I cannot completely R/O perimortem trauma (unknown type), char. by a focal round hole over the right scapula with extensive postmortem scavenging (DDx PM wear through pelage due to continuous sand abrasion and autolysis, followed by scavenging). Unfortunately advanced decomposition and scavenging prohibit precise assessment of this finding. Because this animal was extremely sandy and the hole in the skin was over bone (scapula), postmortem abrasion/ wear is possible. No tooth scratches or shark tooth fragments were found.

Extensive scavenging of the lungs and cranial chest wall was apparent. Also noted was a small triangular area of mild endocardial hemorrhage on the aortic outflow. There is a low possibility that this lesion is scavenging-associated (eg if the skin laceration was present antemortem and scavenging of the thoracic viscera commenced prior to this animal’s death).

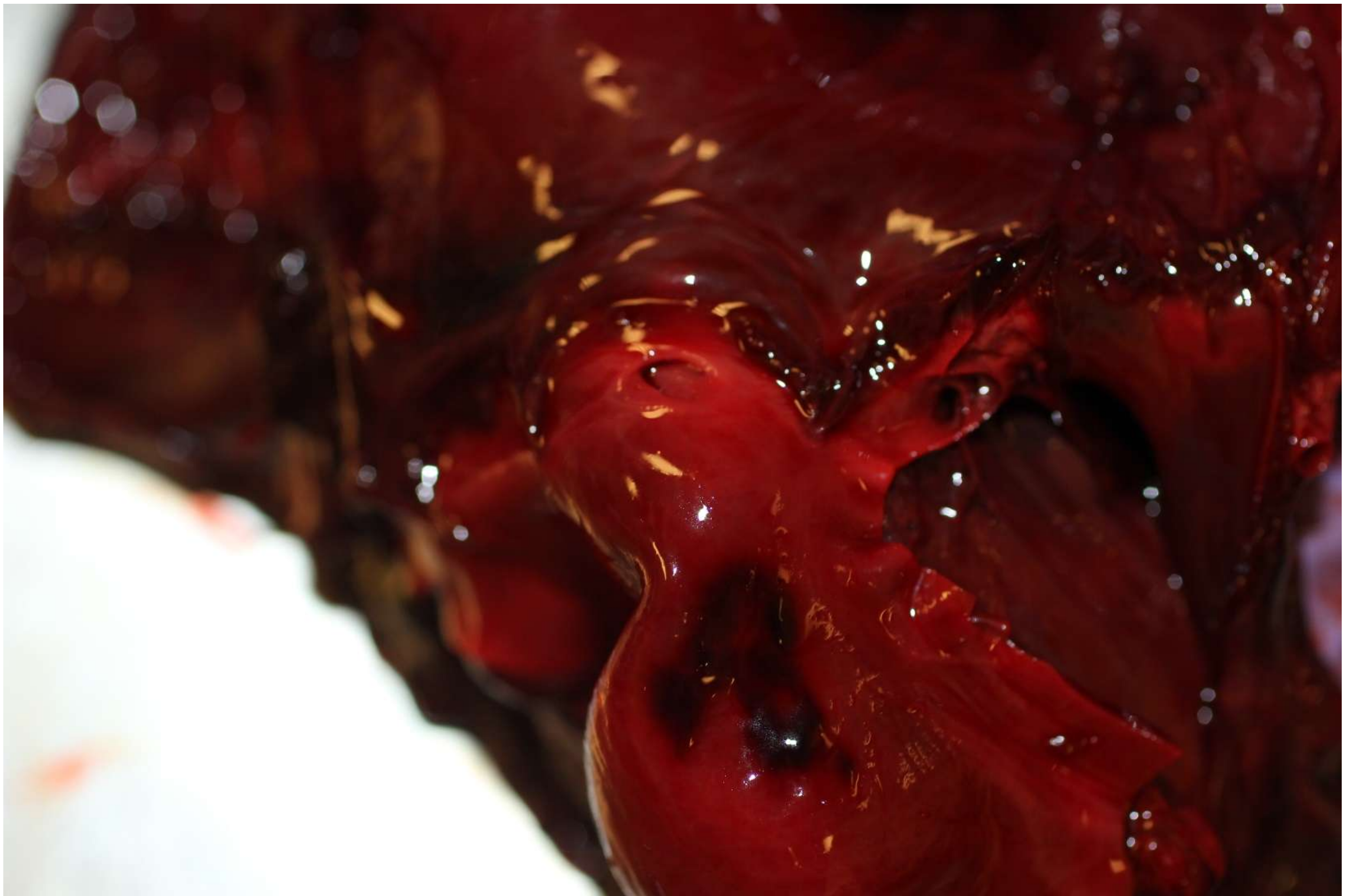
The markedly distended and red-black discolored stomach is also of some concern because it could be indicative of perimortem gastric bloat. However, precise assessment was limited by advanced decomposition. Diffuse, marked red-black discoloration was present on both the serosal and mucosal gastric surfaces, but mainly spared intestine. The stomach and intestines did not contain any food.

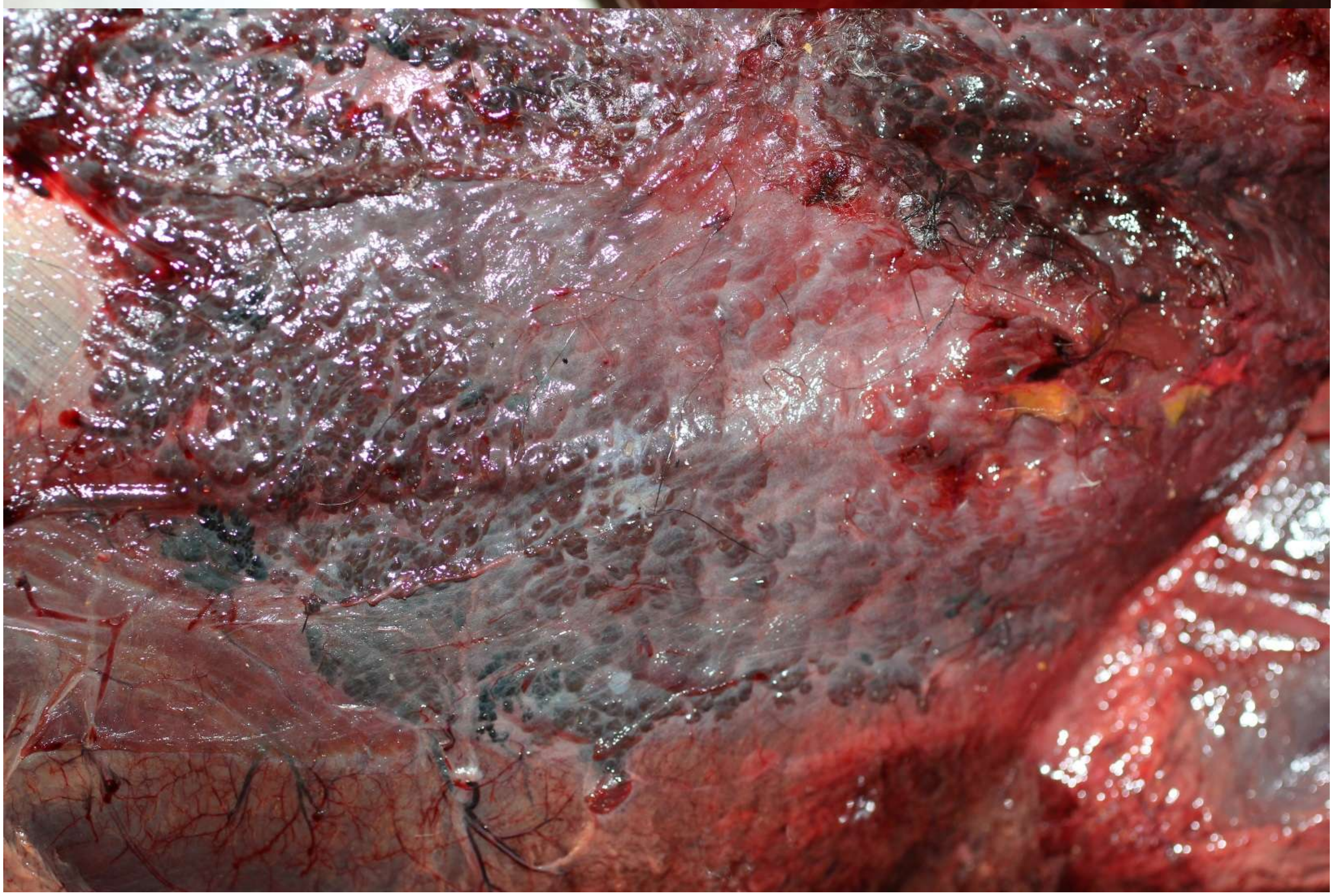
Limited histopathology will be performed to further assess the gastric wall, mammary gland, twisted omentum and heart. Because of advanced autolysis, histopathology may not add any additional case insight, but it is worth a try.

Top: Remainder of flipper tag left flipper Bottom: Hole in left flipper (old tag site)

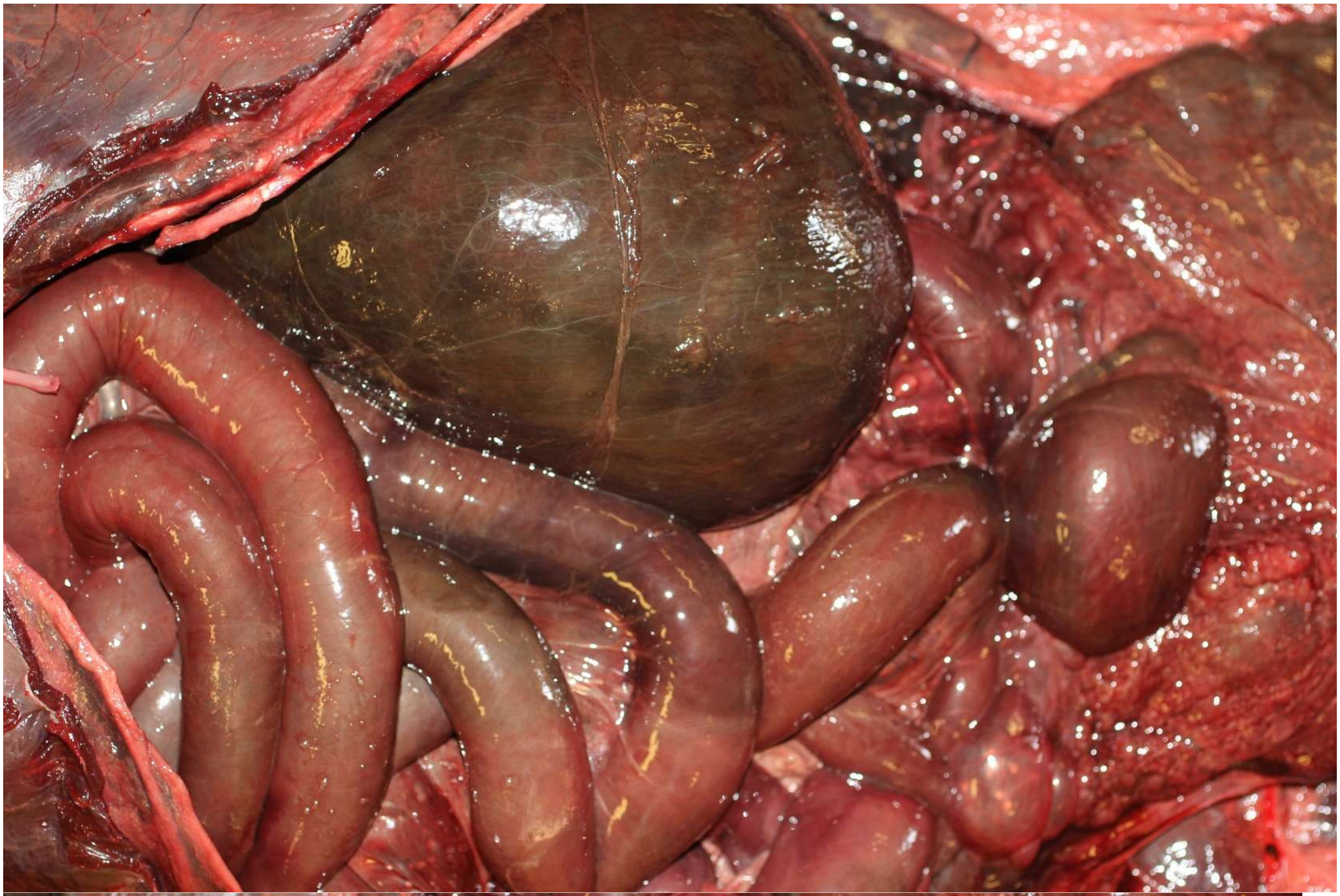
Top: Dentition Bottom: Hole in skin, right axilla

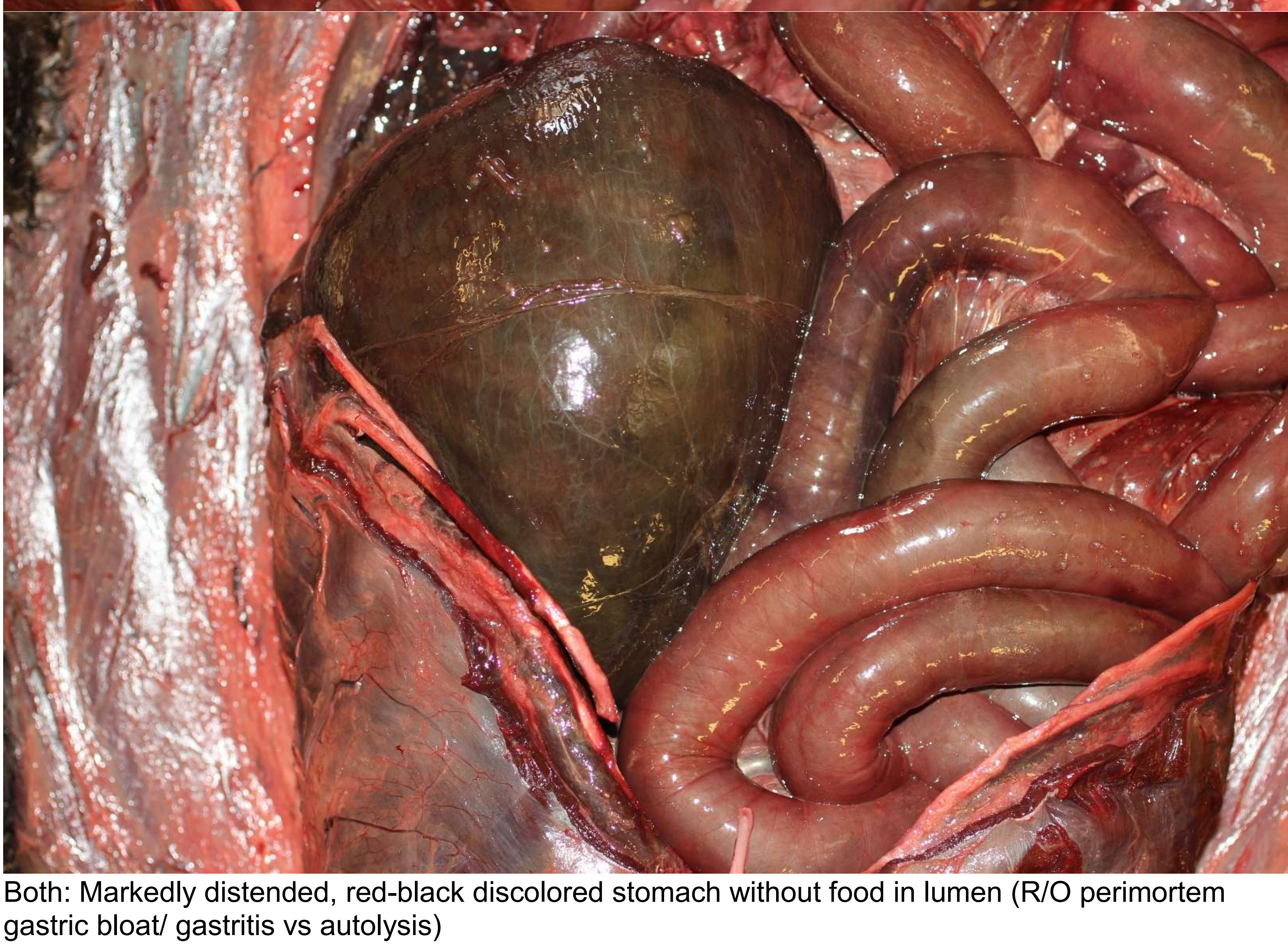
Top & bottom: Extensive scavenging of chest



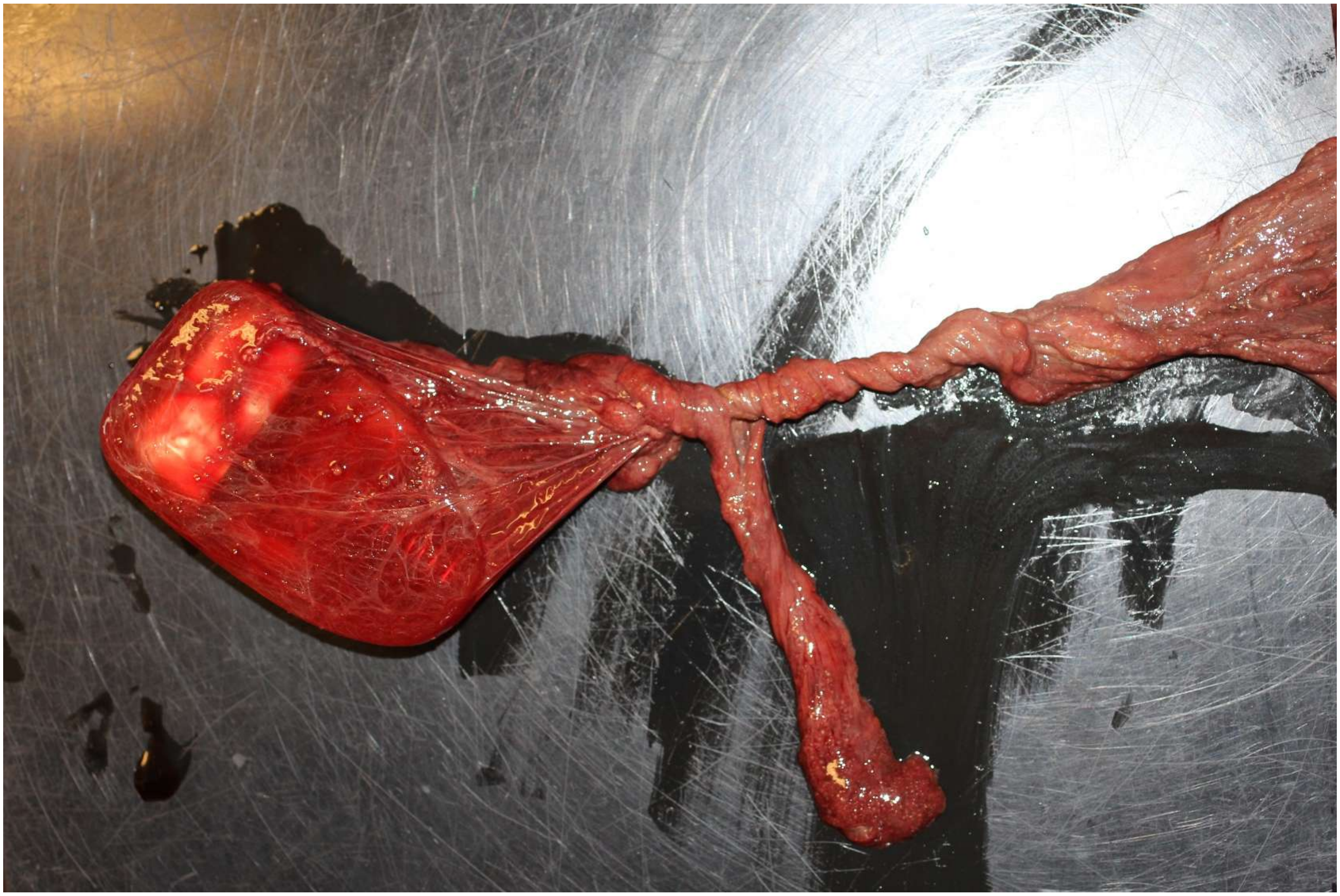


Top: Focal endocardial hemorrhage aorta
Bottom: Large well-developed mammary glands, no lactation





Both: Markedly distended, red-black discolored stomach without food in lumen (R/O perimortem gastric bloat/ gastritis vs autolysis)


VHF transmitter entrapped and tightly boloed in omental bursa

CDFW SEA OTTER NECROPSY REPORT

California Department of Fish and Wildlife
Office of Spill Prevention and Response
Marine Wildlife Veterinary Care and Research Center
151 McAllister Way
Santa Cruz, CA 95060
(831) 469-1719

Sea Otter:	8744-18
UCD PATH:	18S0106
MWVCRC Necropsy	18-0023
Report Date:	2/13/18
Report Status:	Gross

CASE PROFILE

DFG/BRD#: 1330
UON#: N-1606-14-S
MBA#:
Date Found: 2/10/2018
Condition Found: Fresh
Live Strand: No
Euthanized: No
Date Died:
Total Length (cm): 121
Weight (kg): 17.7
Nutritional State: Good
SQ Fat: Moderate
Food in Gut: None

Report By: **Dr. Melissa Miller**
Necropsy By: MM, ED, FB, CY, AW
Necropsy Date: 2/12/2018
Condition: Fresh
Sex: Female
Age Class: Adult
Estimated Age: 5-7 MM
Location: Del Monte Beach, just N of Casa Verde Condos
County: Monterey
ATOS: 372
DSOFS COD: 11p
Histopathology:

DATABASE CODING

Code11p (PT)
Primary COD
DA
intoxication,
acute/
subacute,
pres
Sequela 1
Sequela 2
Secondary COD
Cardiomyopathy,
A/SA
Tertiary COD
Perimortem
seawater
aspiration

CASE BACKGROUND

23Sept2014 captured off MBA, VHF only 166.022, 18.55kg, 113.7cm TL, estimated at 3 years old by M. Staedler

Here is Yelsi's factsheet. By the time I found her carcass, it was after sunset, so I did not get a very good look at her carcass. She seemed super fresh though, with no obvious trauma.

Yelsi (Yellow SIlver) has been part of the NSF study, but tagged originally in 2014. We generally resight her from Hopkins to Otter Point, but she has been seen as far north as NPS, and as far south as the Great Tide Pool. She forages primarily on kelp crab, fat innkeeper worms, urchins, mussels, and chitins.

She was last seen a couple days ago with her 10 week old pup. I think yesterday, trackers recorded a weak radio resight off Otter Point.

Per Michelle S. update, she had an antemortem Hx of 4 pups observed.

GROSS DIAGNOSES

1. Domoic acid intoxication, acute to subacute, pres. char. by:
   -Acute death with glossy pelage in good nutritional condition
   -No food in GI tract
   -Moderate/ severe multi-organ congestion esp. liver and kidneys (see also #2)
   -Marked diffuse meningeal and neuropil congestion and mild/ mod cerebellar coning
   -Possible multifocal meningeal hemorrhage
   -Hyphema <u>OD</u> (Eye scavenged <u>OS</u>-Mistake in case notes)
   -Scant blood-tinged CSF (Mild dehydration)
   -Urine pale yellow, 50 ml

2. Cardiomyopathy, mild acute to subacute (Same as #2, pres.) char. by:
   -Mild patchy myocardial mottling
   -Mild diffuse venous engorgement, ventricular myocardium mildly and diffusely brown-discolored
   -Probable acute myocardial hemorrhage in papillary muscles of left ventricle
   -Mild peritoneal effusion (20-30 ml)
   -Pericardial effusion, mild (6+ ml)

3. Probable perimortem seawater aspiration (+/- acute cardiac failure), characterized by:
   -Marked diffuse pulmonary edema and pleural effusion (200 ml)
   -Red-tinged fluid in mouth, nose, airways, lungs, stomach and staining hairs around nose and mouth

INCIDENTAL FINDINGS

1. Mid/ late stage 3 female:
   -Large mammary glands, moderate adipose, mild diffuse muscle atrophy/ catabolism
   -Moderate SQ adipose, mild muscle atrophy
   -CA's: Left 2+, right 1+
   -Uterine horns small and symmetrical
   -Placental bands L& R (larger/ most recent is on left)
   -Cervix small, closed, non-bruised, mild vulvar swelling (cardiogenic?)
   -Nose wounds small, white

2. Ventral midline surgical scar unremarkable, VHF free-floating, no TDR

3. Small SQ cyst right lateral neck near retropharyngeal LN (R/O residual branchial cleft cyst on HP)

4. Left nipple mildly bloody, underlying mammary gland normal (Perimortem trauma, pres.)

5. Possible small/ mild viral plaque, ventral tongue

6. Mild intestinal Corynosoma

GROSS SUMMARY

Pending histopathology and biochemical testing, the presumptive cause of death is acute/ subacute DA intoxication with associated cardiomyopathy and terminal seawater aspiration.

The fresh carcass of an approx. 1 week old, acutely dead pup in excellent nutritional condition and with a GI tract full of milk (NOT matching the age of this female's pup) was recovered in the same area 3 days later and was necropsied 2/13/18. Gross lesions for the pup were more moderate, but were otherwise similar to this case. A partial fresh necropsy was performed on that case, including collection of coagulated milk from the full stomach. These two cases will be worked up in tandem.

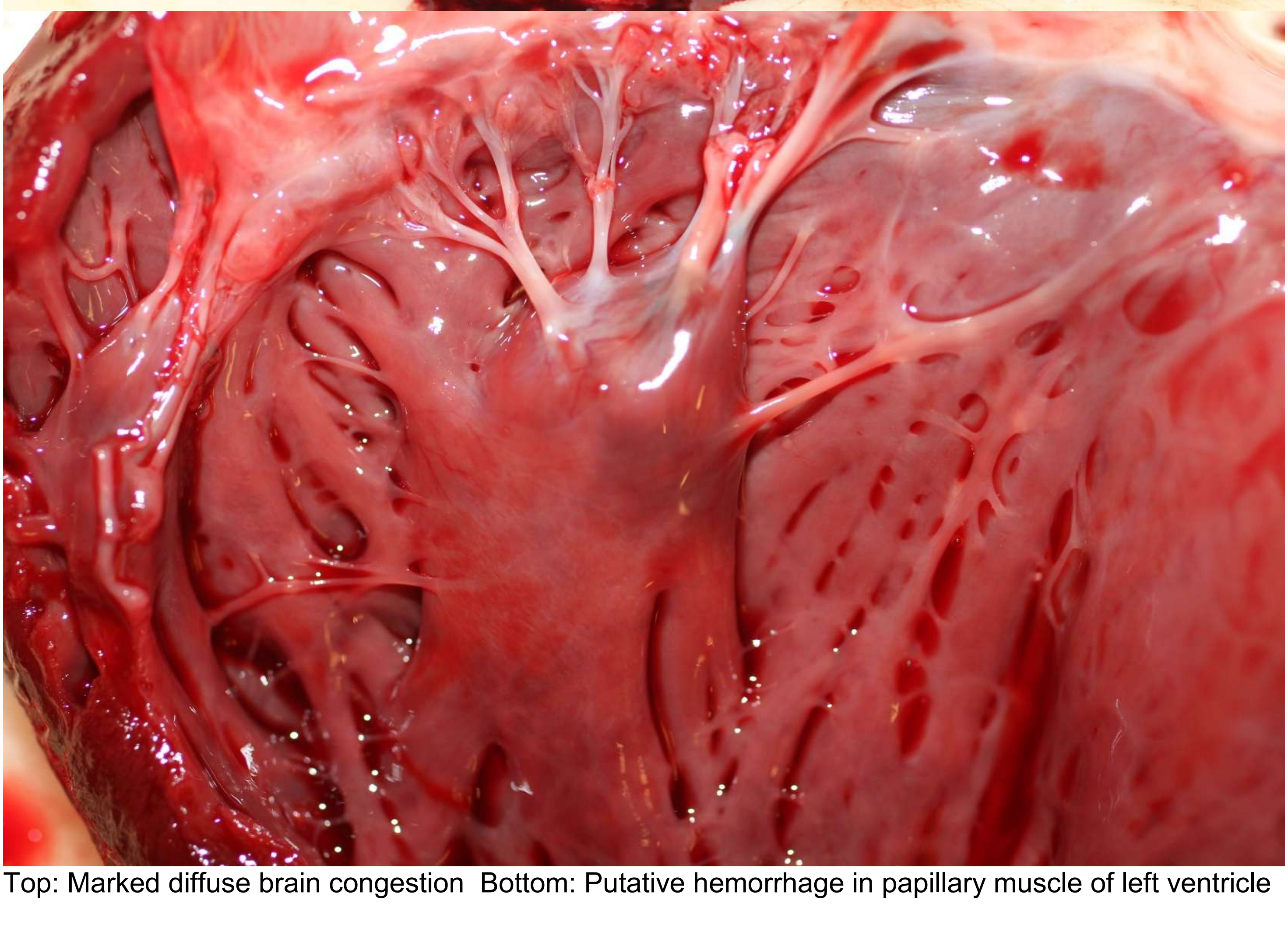
Note: Both animals stranded in an area where a large (approx.. 5 million gallon) sewage spill had occurred approx.. 1 month prior, and where a regional HAB event with STX production and bioaccumulation in shellfish had occurred over the past few weeks. A few birds had also been reported exhibiting neurological disease from this area over the past few weeks. HP and further testing are pending.

Saved:

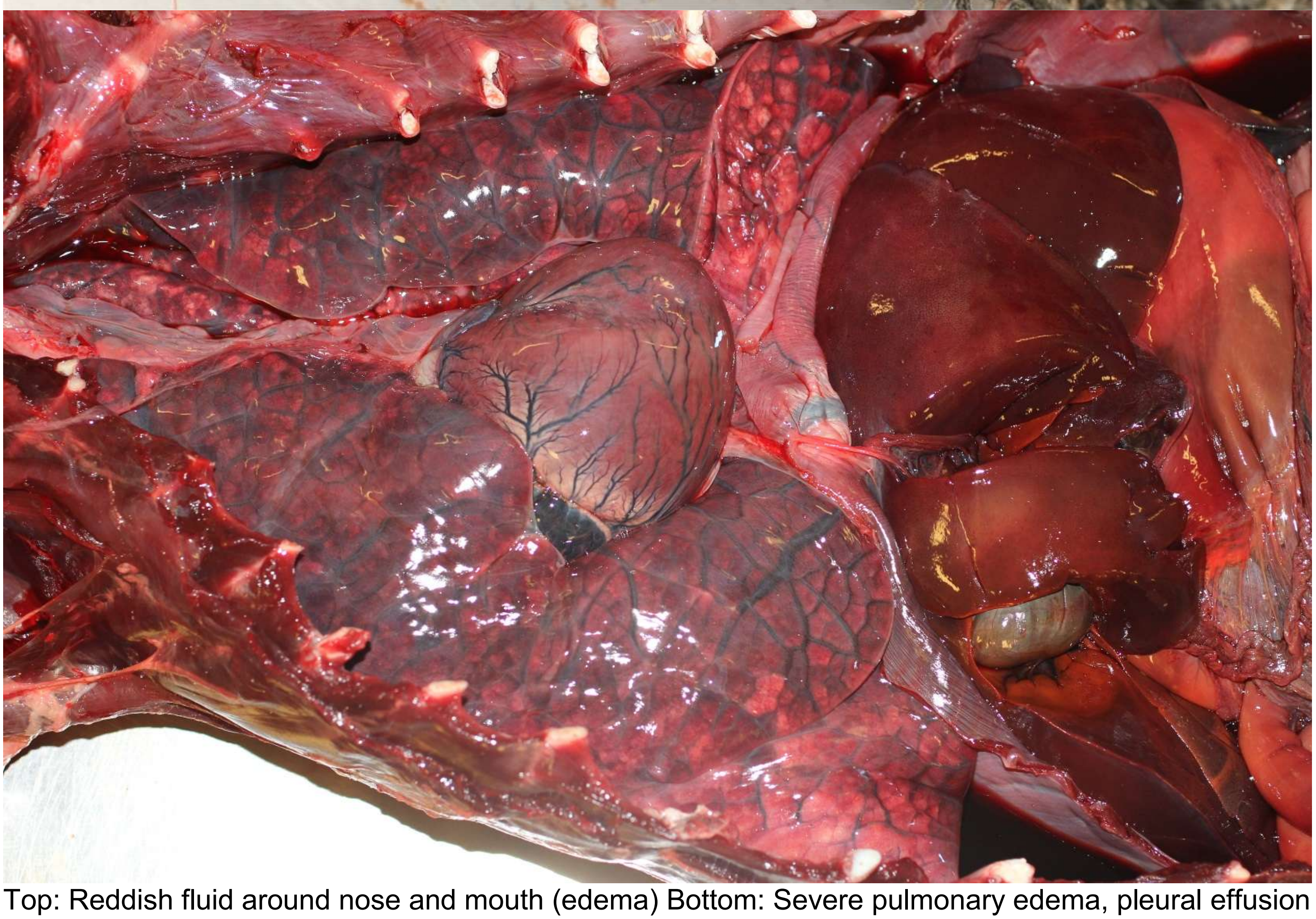
- Gross photos
- Full sample set frozen and HP
- Demodex & mycoplasma samples
- Hair & whisker, tooth
- Urine, PCF, serum, CSF (drop w/ blood contamination) (No food)

Next steps:

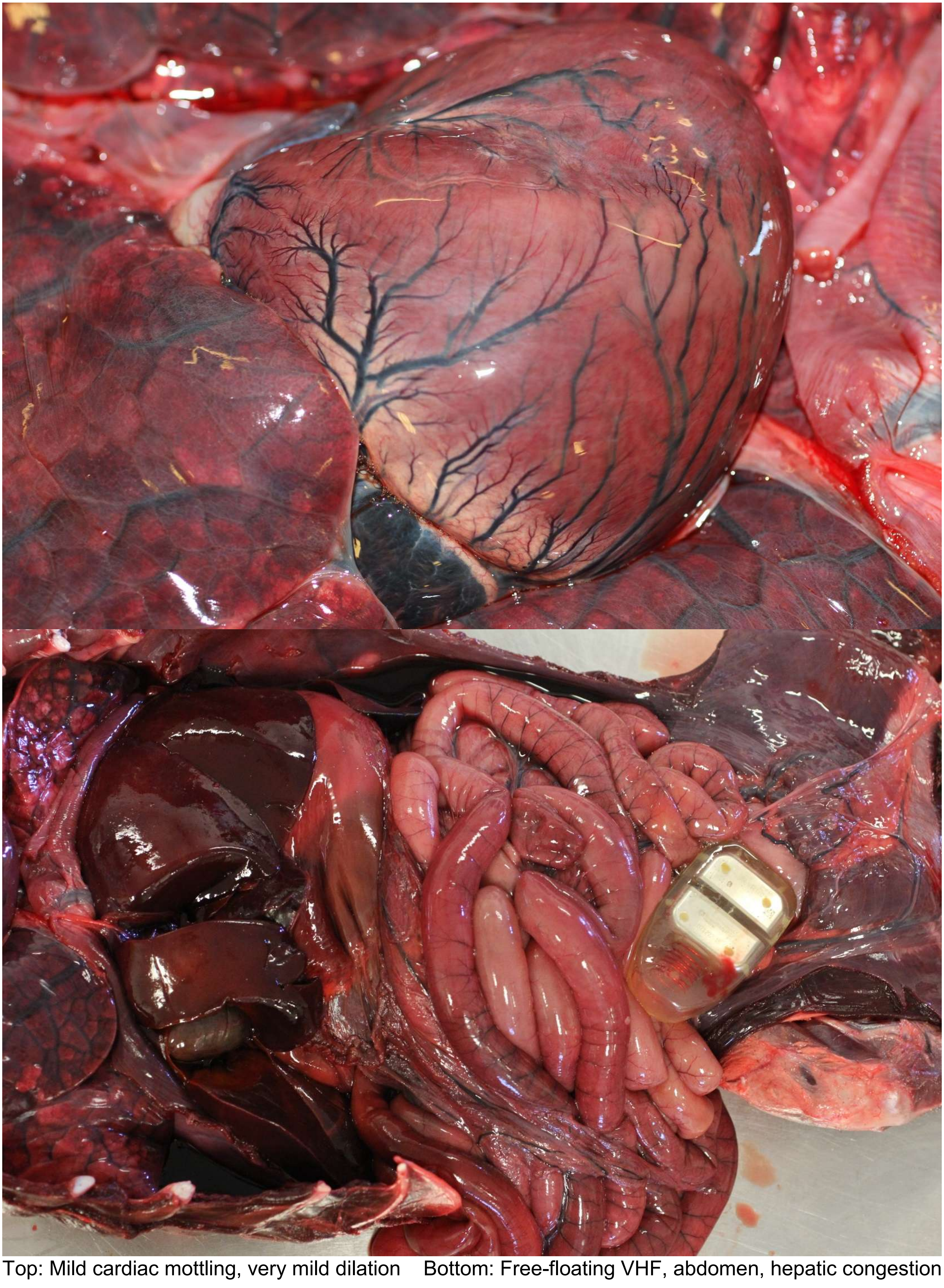
- Examine suspect pup from this animal 2/13/18 (Found fresh dead 2/12/18)
- MM to assist with brain trimming for both (trim in all CVOs)
- Test urine for DA (both if possible)
- Full histopathology x 2



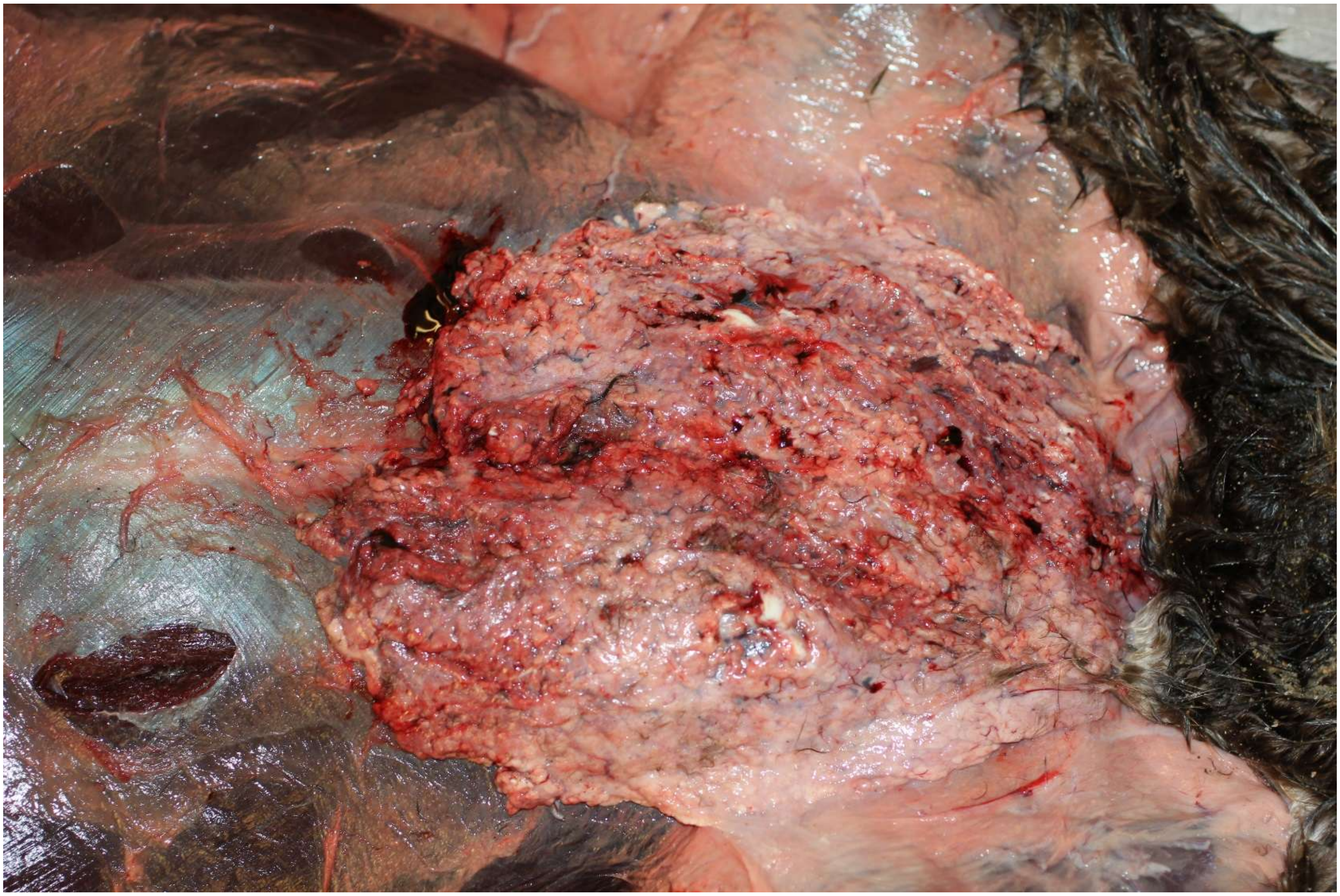
Top: Marked diffuse brain congestion Bottom: Putative hemorrhage in papillary muscle of left ventricle



Top: Reddish fluid around nose and mouth (edema) Bottom: Severe pulmonary edema, pleural effusion



Top: Mild cardiac mottling, very mild dilation   Bottom: Free-floating VHF, abdomen, hepatic congestion


Prominent mammary glands (Mid/late stage 3 female: first ½ of pup care)

STRANDED SEA OTTER FACT SHEET

SO# 8770-18

PERSON REQUESTING SO#: J. Fujii

DATE FOUND: 05 (DD) Mar (MMM) 2018 (YYYY)

MWVCRC# 18-0099

FOUND BY: PC RPC BO PM SBS ✓ SOB BIO UU — Patty Brown

OTHER# BRD 1358-16

RECOVERY AREA: 12 **ATOS:** 341 **LAT / LONG (DD):** N 36.7267 W -121.8061 TC ✓ / GE

RECOVERY LOCATION: Salinas River National Wildlife Refuge (CITY / COUNTY; LOCATION DETAILS, LANDMARKS) **TAR ON BEACH:** N ✓ / Y / ?

COND: 1=ALIVE (EUTH: Y / N) 2=FRESH 3=MOD DECOMP 4=ADV DECOMP ✓ 5=MUMM/FRAG/SKEL 9=? **SCAVENGED:** 0=NO 1=SLIGHT 2=MOD ✓ 3=HEAVILY 9=?

SEX: F / M ✓ / ? **AGE:** 2=PUP 3=IM 4 or 14=SA 5 or 15=AD ✓ 6=AGED AD 7=PUP OR IM 8=SA, AD, AA 9=?

TAGGED: N / Y ✓ / ? (Y=PG 2) **TAR ON OTTER:** N ✓ / Y / ? **OBV TRAUMA:** N / Y ✓ / ? **EST AGE:** 7-8 W / M / YR ✓ **BY:** CY, MM

TL: 129.5 CM **TAIL:** 29 CM **WT:** - KG **NOSE WOUND:** SIZE: N FRESHNESS: N

TEETH: 5=ALL MILK 6=SOME MILK 1=EXC 2=GOOD ✓ 3=FAIR 4=POOR 9=? REMARKS:

ECHINO: 0=NONE 1=SLIGHT 2=OBVIOUS ✓ 9=? (SKULL OR PCS EXAMINED, SEE BACK) REMARKS: Interesting echino pattern (skull saved)

GRIZZLE: 6=NATAL 7=JUV BUFF 1=NONE TO SLIGHT 2=TO EYES 3=TO LAMBDOIDAL CREST 4=TO CHEST ✓ 5=TO TAIL 9=?

RED ALGAE ON FUR: N ✓ / Y / ? VISUAL / UV LAMP ✓ 1=< 2% 2=2-10% 3=11-20% 4=>20% REMARKS:

NECROPSY: NO / F ✓ / G / D BY WHOM: B / BP / V / VP / P ✓ M. Miller, C. Young, K. Greenwald DATE: 06 Mar 2018

COND AT NEC: 2 / 3 / 4 ✓ / 5 **PREV FROZEN:** N ✓ / Y **LOCATION OF NECROPSY:** MWVCRC

SUBCU FAT: 0=NONE 1=SCANT 2=FAIR 3=MOD 4=ABUND 9=? ✓ **TARRY DIGESTA:** 0=NOT OBVIOUS 1=SLIGHT 2=OBVIOUS 9=? ✓

FOOD IN GUT: 0=EMPTY 1=LITTLE 2=MED 3=FULL 9=? ✓ PREY:

ACANTH: UNK ✓ / NO / C / P / C=P / CP / PC INT: 0=NONE 1=MILD 2=MOD 3=HEAVY 9=? ✓ AB: 0=NONE 1=MILD 2=MOD 3=HEAVY 9=? ✓

FETUS: N=NO ✓ Y=YES, NO SEX M=YES, MALE F=YES, FEMALE U=? TL: - CM CR: - CM WT: - GM

WOUNDS CHARC OF SHARK BITE: N / Y / ? ✓ **EFFORT TO CONFIRM:** 0=NONE 1=CURSORY 2=INTENSIVE ✓ 3= NA

WOUND DESCR: 1= NO OBVIOUS HEALING 2= INDICATION OF HEALING ✓ 3= INDICATION OF INFECTION 4= OBVIOUSLY OLD, HEALED 5= ? 6=NA

EVIDENCE WOUNDS ANTE-MORTEM: Y ✓ / ? / NA IF YES: SQ HEM OTHER: Healing

REMARKS:
From J. Fujii: Otter Name: Hagrid, N-1634-16-S, BRD 1358-16. Captured 6/2/2016 off Lover's Point as part of NSF research project. Given Radio (167.632) and TDR #1690058. Was 28.4 kg at capture. Generally seen offshore between Pt. Pinos and Del Monte Beach. Very little forage data, but mostly sandy prey (Fat innkeepers, crabs, clams, etc). Was last seen Feb 18, 2018 in Monterey Harbor. Looked emaciated and with potential fight wounds on flippers, tail, and nose.

Multiple full-thickness lacerations on flippers and tail with scant rounding of skin margins (scant healing). Lacerations on dorsal and ventral surface of phalanges with no visible scratches or tooth fragments. No other lacerations on body. Some lacerations rounded, others v-shaped, one long linear (~4cm). On opposite flipper skin was grooved and hair removed in linear to v-shaped pattern. No apparent nose or facial wounds. Trauma consistent with either VERY severe fight trauma or mild, focally extensive suspected shark bite (early subacute). Also thin to emaciated. TDR in falciform VHF in abdomen. All abdominal viscera and all pelvic muscle scavenged. PIT tag missing. Heart and lungs WNL (for advanced autolysis case). If trauma was caused by shark, the link to the COD is uncertain due to the location of the wounds and comparative mildness of the wounds.

PREMOLAR: N / UR UL ✓ LR LL **FUR:** N / Y ✓ **WHISKERS:** N / Y ✓ **OTHER SAMPLES:** N ✓ / Y (Y=SEE BACK) **PHOTOS:** N / Y ✓

CAUSE OF STRANDING: 2 **IF CODE=10 OR 11, THEN PRIMARY:**

OTHER SIGNIFICANT FINDINGS:

DISPOSITION: CARCASS: 0 PELT: 0 SKELETON: 0 SKULL: 192 BACULUM: 0 PREMOLAR: 192

FACTSHEET2016_V1

CONTINUE ON BACK: N / Y ✓

SO# 8770-18

TAG REF #: 1358-16 **KNOWN AGE:** N / Y **IF YES:** KA<3 MO KA<6 MO KA< 12MO

TAGS: R: TQ / 3/4 / ____ (COL / POS / NO.; MISSING? Y / N) **L:** LG / 4/5 / ____ (COL / POS / NO.; MISSING? Y / N) **PIT:** 985141000930593 **WORKING:** Y / N / ?

TAG HX:
N-1634-16-S, BRD 1358-16. Captured 6/2/2016 off Lover's Point as part of NSF research project. Given Radio (167.632) and TDR #1690058. Was 28.4 kg at capture.

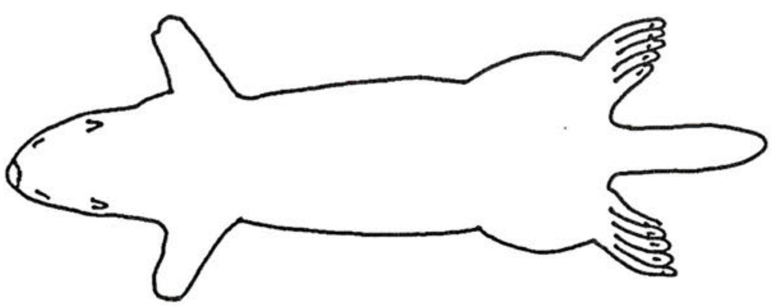
ECHINO: SKULL: 0=NONE 1=SLIGHT 2=OBVIOUS 9=? **PCS:** 0=NONE 1=SLIGHT 2=OBVIOUS 9=? REMARKS:

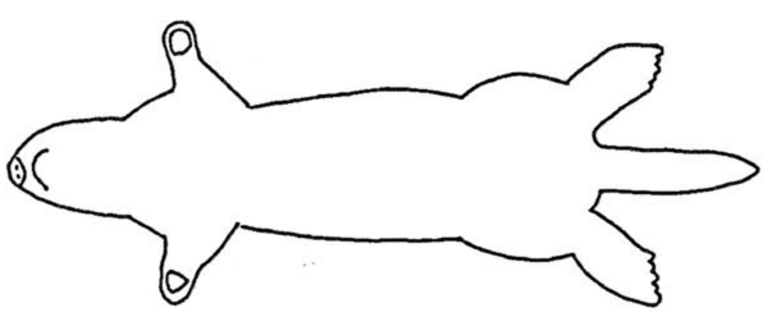
SAMPLES TAKEN: BI=BILE BL=BLOOD BR=BRAIN GC=GUT CONTENT HE=HEART KI=KIDNEY LI=LIVER LN=LYMPH NODE LU=LUNG MU=MUSCLE SP=SPLEEN UR = URINE ALL OTHER: NONE
FOR WHAT: WHOM:

HISTO SAMPLE: FULL / PARTIAL NONE

XRAY: 1=YES,GUNSHOT 2=YES,NOT GUNSHOT 3=YES,GUNSHOT:OLD HEALED WOUND

ADDITIONAL REMARKS:





CDFW SEA OTTER NECROPSY REPORT

California Department of Fish and Wildlife
Office of Spill Prevention and Response
Marine Wildlife Veterinary Care and Research Center
151 McAllister Way
Santa Cruz, CA 95060
(831) 469-1719

Sea Otter:	8776-18
UCD PATH:	18S0187
MWVCRC Necropsy:	18-0143
Report Date:	3/15/2018
Report Status:	Gross

CASE PROFILE

DFG/BRD#:	1133	**Report By:**	Miller
UON#:	N-1408-09-S	**Necropsy By:**	Miller, Dodd, Greenwald
MBA#:		**Necropsy Date:**	3/14/2018
Date Found:	3/8/2018	**Condition:**	Fresh
Condition Found:	Fresh	**Sex:**	Female
Live Strand:	No	**Age Class:**	Aged Adult
Euthanized:	No	**Estimated Age:**	10-12 MM
Date Died:		**Location:**	Floating off Monterey Bay Inn
Total Length (cm):	119	**County:**	Monterey
Weight (kg):	18.4	**ATOS:**	379
Nutritional State:	Emaciated	**DSOFS COD:**	11P
SQ Fat:	None	**Histopathology:**	Partial
Food in Gut:	None		

MORTALITY DATABASE CODING
Mortality Code 11p

Primary COD Cardiomyopathy
Sequela 1 Suspected coagulopathy/ DIC

Secondary COD Gastric ulcers/ melena

Tertiary COD Nephrosclerosis

Quaternary COD Marked tooth wear

5th: Emaciation (+/- prior ELS)

CASE BACKGROUND

Captured 8/24/09 off MBA, 17.9 kg, 116.6 cm TL, estimated age 8 yrs, no VHF, no TDR. 66 resights from Aug 2009 - 2010, no foraging data.

GROSS DIAGNOSES

Animal was partially frozen-thawed, and carcass held for a few days post-thaw because tag holes were not reported at the time of carcass collection. Tag holes found during preparations for a “gorpo session” at MWVCRC, and animal was set aside for pathologist examination.

1. Cardiomyopathy, subacute to chronic, moderate/marked, char. by moderate to marked myocardial pallor and streaking, esp. LVFW and atria

- Left and right heart failure, subacute to chronic, char. by hepatic passive congestion & hepatomegaly, & moderate pulmonary septal fibrosis & marked peritoneal, pleural, pericardial and subcutaneous effusion, bilateral pleuropulmonary venous shunts from ventral lungs to dorsal chest wall

1a. Suspected coagulopathy/ DIC characterized by mild fibrinous deposits at hepatic hilus & moderate/ severe acute hemoabdomen, multifocal SQ hemorrhage, moderate & cyanosis of pallor of gingiva, markedly pale heart and lungs, & scant blood in ventricles and atria (DDX acute hepatic thrombosis, but no definitive antemortem thrombi were found at gross necropsy)

2. Gastric ulcers and melena, moderate

3. Possible moderate bilateral nephrosclerosis secondary to cardiac disease & advanced age

4. Marked tooth wear

5. Late stage 5 female, likely early peri/post blastocyst-implantation pregnant in right uterine horn (but no fetus observed grossly)
   -Emaciated (Doesn’t qualify as ELS at time of death due to presence of a large, well-developed CL, but may well have been ELS case that survived just beyond the ELS time frame)
   -Medium white nose wound
   -Regressing mammary glands, no lactation, trace milk in left teat cistern (<100 ul)
   -Nipples very small and fully haired
   -Vulva mildly swollen, no bruising or matting
   -Est age MWVCRC 10-12 (estimate of ~18 yrs old based on age assessment on capture records seems a bit high based on necropsy findings from uterus & ovaries?)
   -Left ovary 1+ CA’s, no CLs, no paraovarian cysts, no follicles
   -Right ovary: Large 1.2 cm diameter yellow-pink LC, 2+ CAs, no follicles, no cysts
   -No apparent placental scars left, 2-3 right, right (pregnant) horn contained ~3ml tan cloudy fluid, but no grossly apparent fetus or fetal membranes

6. Emaciation, severe (+/- prior ELS?) (Secondary to 1-5, pres.)

7. Perimortem seawater aspiration pres. (recovered from water)
   -Copious red-stained fluid & froth in/around moth, nose, trachea & bronchi (sec. to #1 & #7, pres.)

INCIDENTAL

Marked bilateral adrenocortical nodular hyperplasia (Geriatric otter)

Focal renal cortical cyst, right kidney

GROSS SUMMARY

Pending histopathology, the putative cause of death is moderate to severe cardiomyopathy resulting in left and right heart failure, and suspected perimortem coagulopathy secondary to severe cardiovascular disease +/- nephrosclerosis.

Histopathology may help confirm whether the cardiomyopathy was a result of domoic acid intoxication &/or protozoal disease. Pending case review, DA is considered more likely due to prominent ventricular streaking that is suggestive of prior cardiotoxicity.

This animal's reproductive tract looked younger than 18 years at necropsy-The estimated age at necropsy was closer to 10-12 years. It would be interesting to see what age assessment via tooth examination yields.

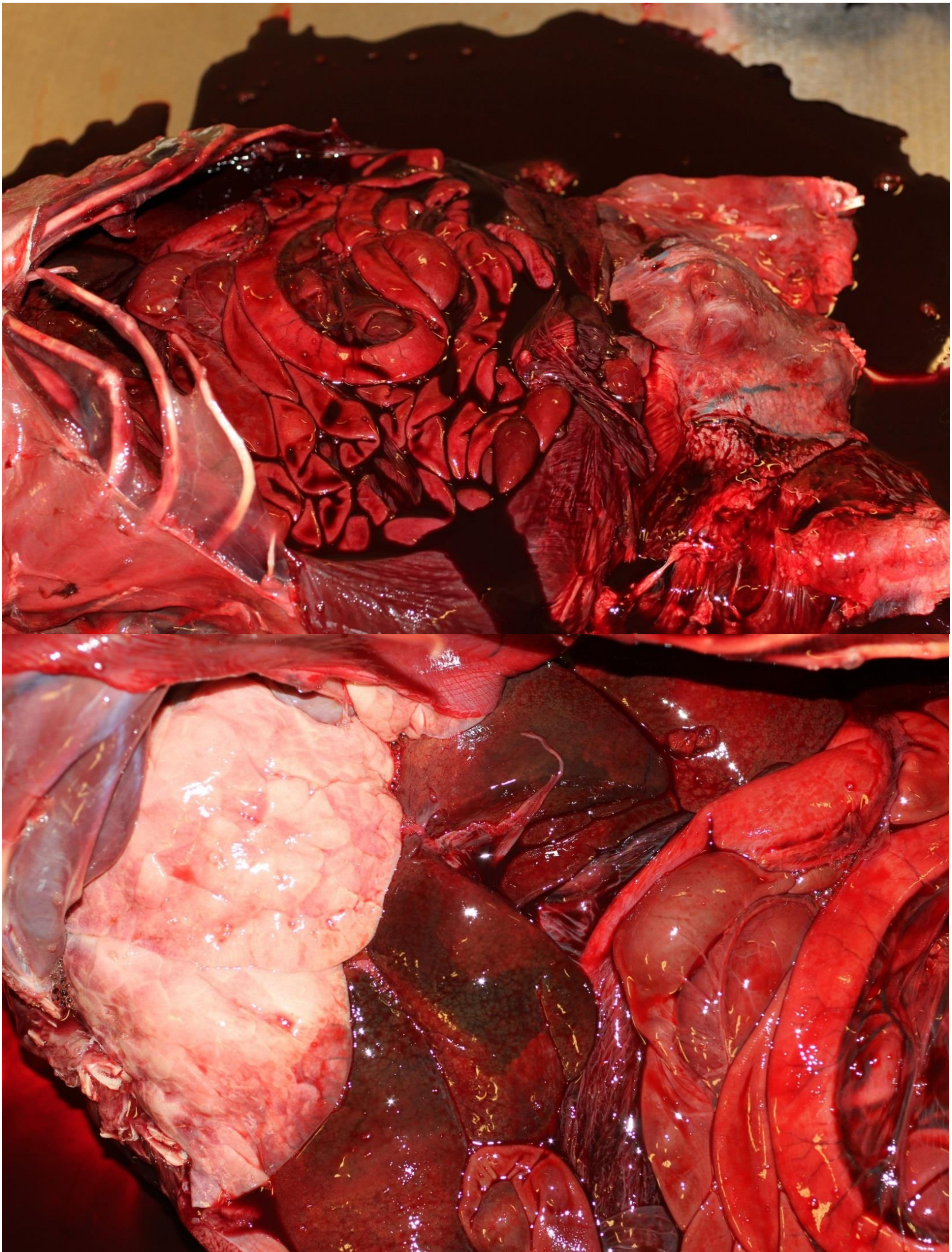
Saved:

Gross photos
Partial histopath: Liver, heart, kidney, lung, tongue,
Frozen: Liver, urine, pericardial fluid, pelage
Room temp: Hair, whisker, tooth

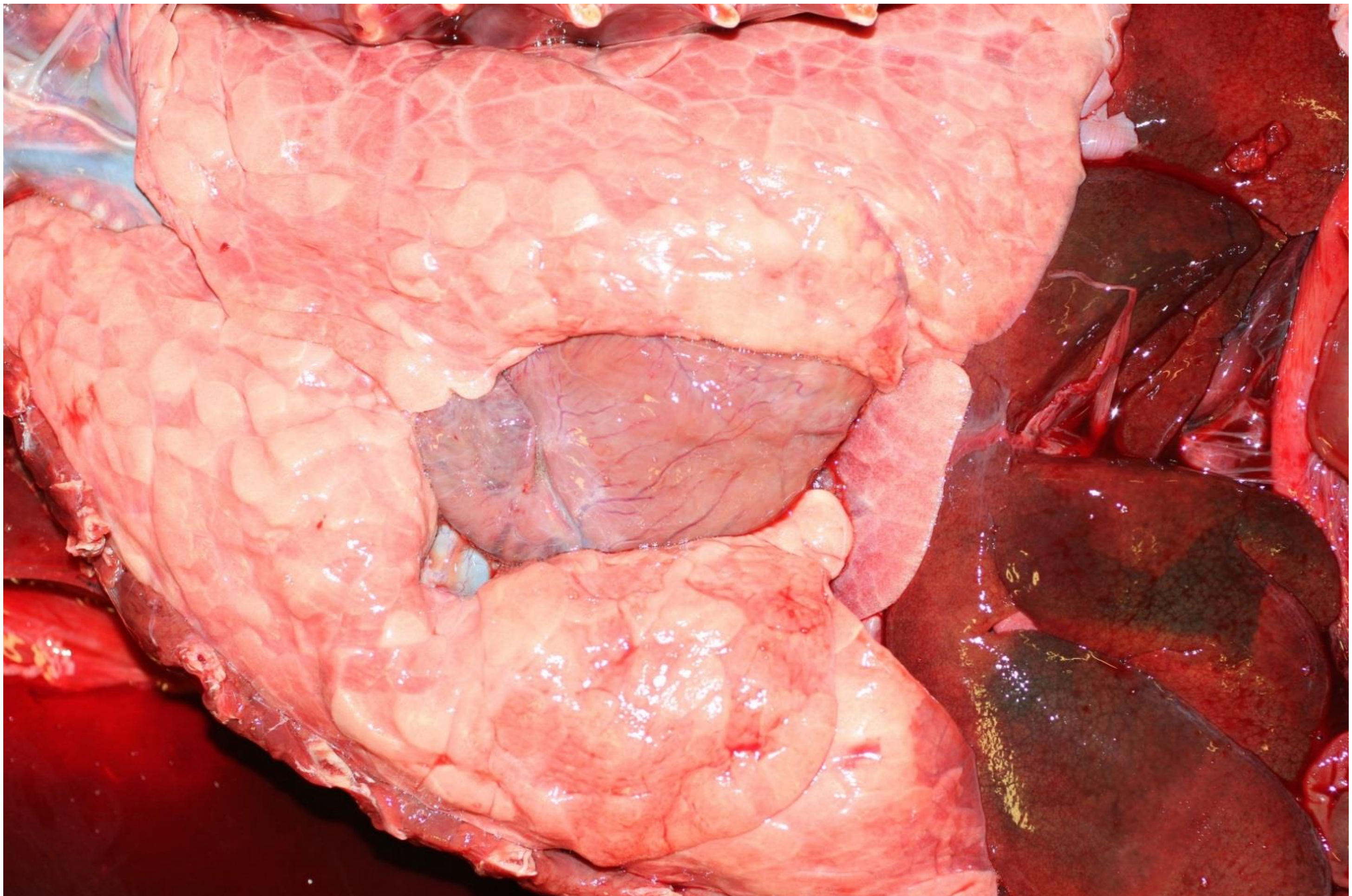
Medium white nose wound & copious red-tinged fluid around nose and mouth

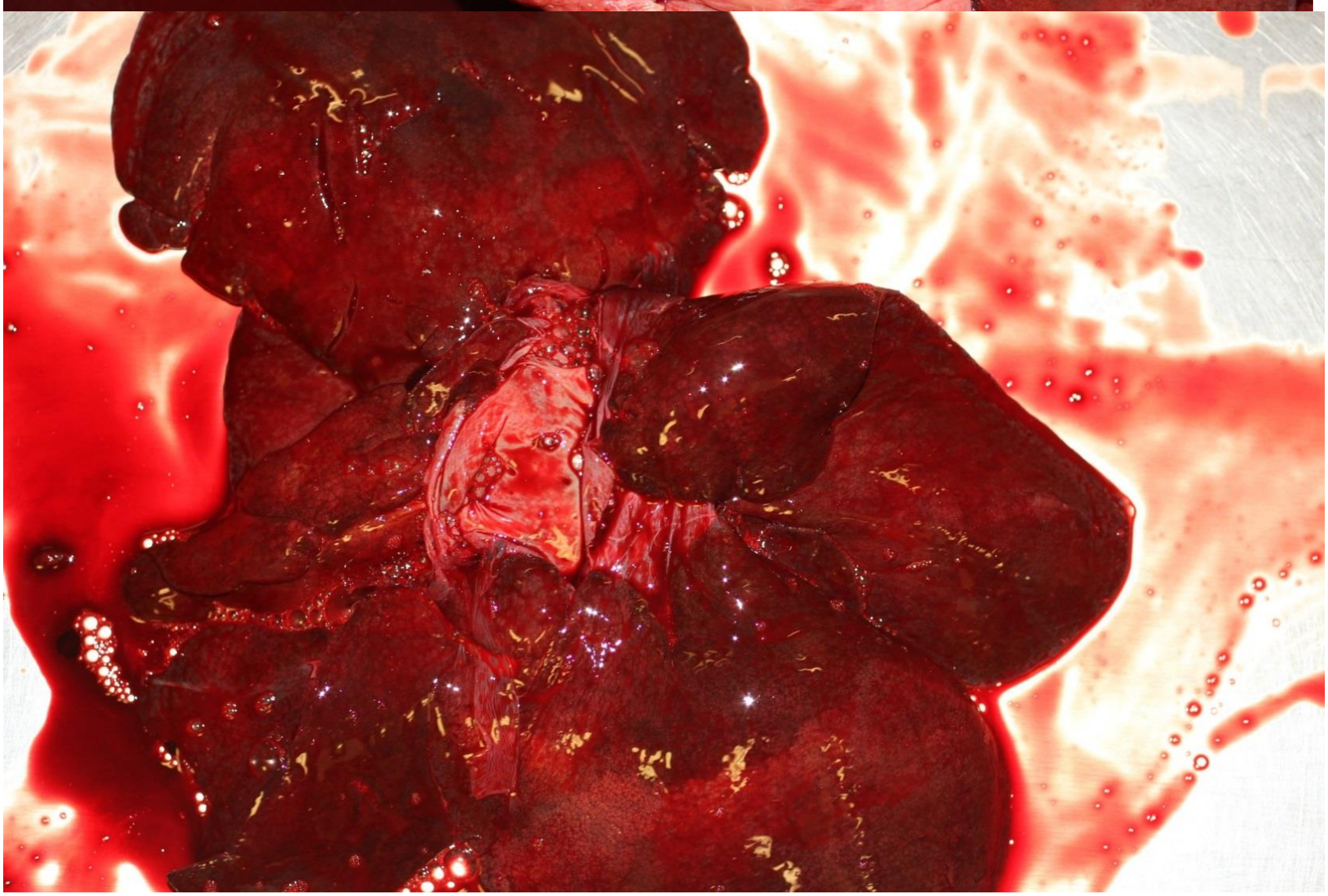
Multifocal acute subcutaneous hemorrhage, right axilla and antebrachium

Multifocal acute subcutaneous hemorrhage, left axilla and antebrachium
Combination of severe peritoneal effusion & hemoabdomen secondary to cardiomyopathy, pres.

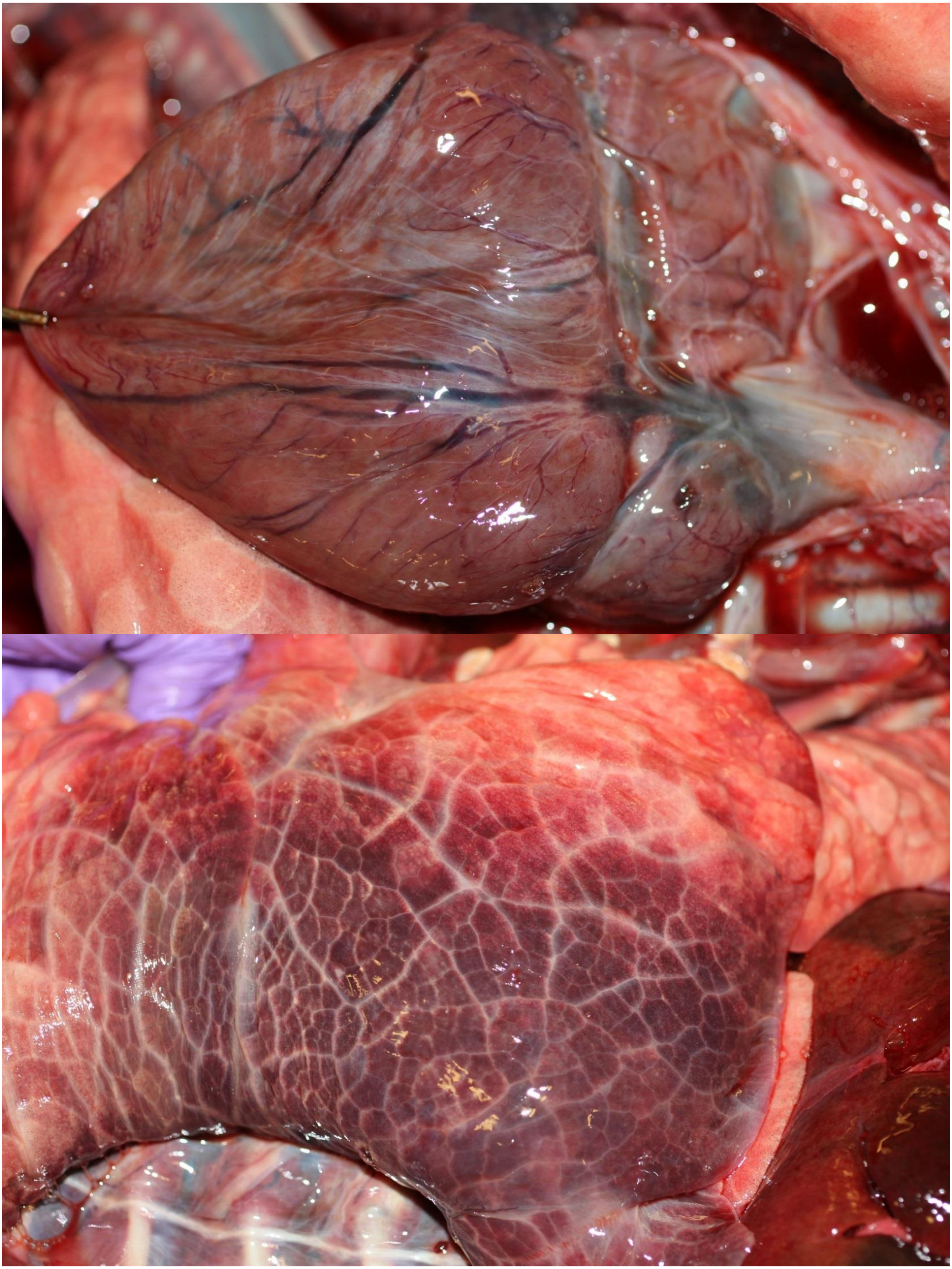


Combination of severe peritoneal effusion & hemoabdomen secondary to cardiomyopathy, pres.
Moderate hepatic passive congestion & hepatomegaly, & diffusely pale, hypoperfused lungs

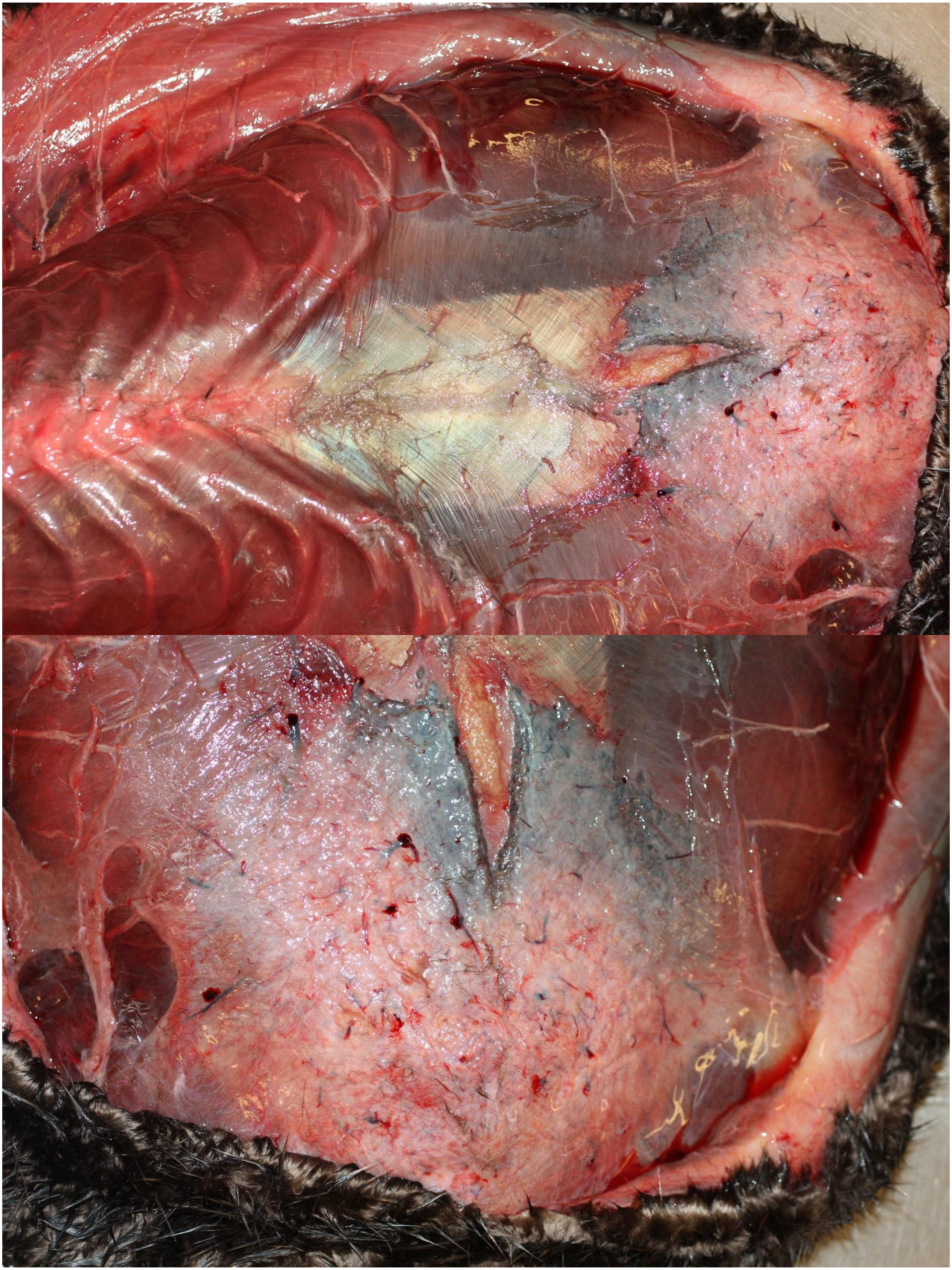




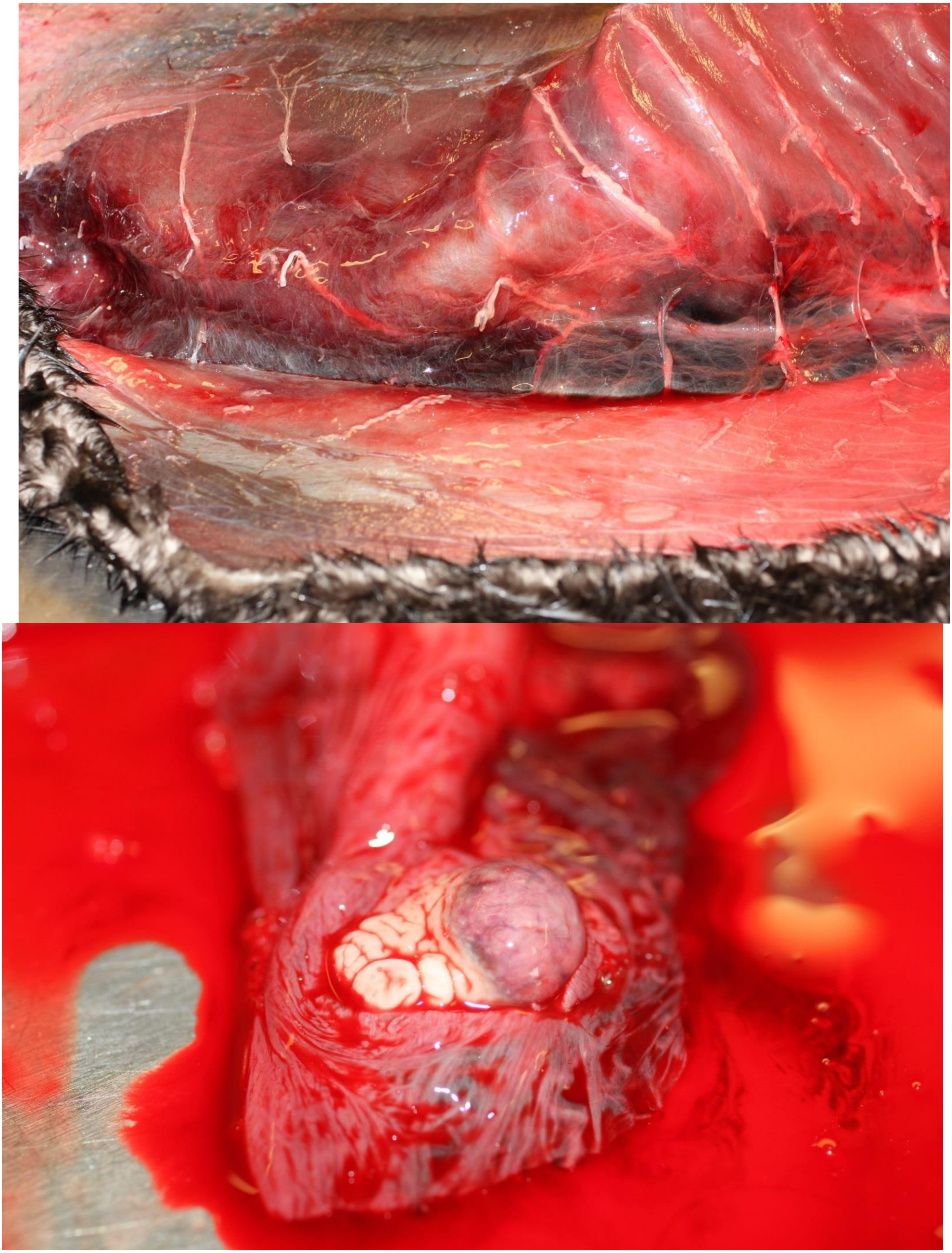
Moderate hepatic passive congestion & hepatomegaly (SA/ chronic right heart failure),
& diffusely pale, severely hypoperfused heart & lungs



Severe myocardial damage (esp. left ventricle and atria) associated with cardiomyopathy
Diffuse moderate pulmonary septal fibrosis (SA/ chronic left heart failure)



Fluid-distended abdomen and regressing mammary glands with no apparent lactation



Top: Possible antemortem SQ effusion (+/- postmortem leakage from abdomen & chest)
Bottom: Large corpus luteum on right ovary (animal was likely post-implantation pregnant, but a fetus was not observed grossly-possibly was still a blastocyst & was too small to see)

CDFW SEA OTTER NECROPSY REPORT

California Department of Fish and Wildlife
Office of Spill Prevention and Response
Marine Wildlife Veterinary Care and Research Center
151 McAllister Way
Santa Cruz, CA 95060
(831) 469-1719

Sea Otter:	8962-18
UCD PATH:	18S0481
MWVCRC Necropsy	18-0262
Report Date:	7/6/18
Report Status:	Gross

CASE PROFILE

DFG/BRD#:	1268	**Report By:**	**M. Miller**
UON#:	N-1546-13-S	**Necropsy By:**	Miller, Batac, Greenwald, Dodd
MBA#:		**Necropsy Date:**	7/6/2018
Date Found:	7/4/2018	**Condition:**	Adv Decomp
Condition Found:	Adv Decomp	**Sex:**	Male
Live Strand:	No	**Age Class:**	Aged Adult
Euthanized:	No	**Estimated Age:**	11-13 years MM
Date Died:		**Location:**	Hollister Ranch,200m E of San Augustine Ramp
Total Length (cm):	133.5	**County:**	Santa Barbara
Weight (kg):		**ATOS:**	1136
Nutritional State:	Excellent	**DSOFS COD:**	3
SQ Fat:	Abundant	**Histopathology:**	Partial
Food in Gut:	Unknown		

MORTALITY DATABASE CODING
Mortality Code 3 (uncertain w/o trauma)
Primary COD Acute DA intoxication possible
Sequela 1 Multi-organ congestion?
Secondary COD Mod/ marked tooth wear
Tertiary COD None
Quaternary COD None

CASE BACKGROUND

Adult male sea otter captured, tagged and implanted with both a TDR and a VHF transmitter on 11 March 2013 at San Augustine in Santa Barbara County. Estimated 7 years of age by M Staedler.

04 July 2018: Sue Benech collected advanced decomposed tagged sea otter and put on ice. 05 July 2018: Brian Hatfield transported from Hollister Ranch and it was put on scheduled TMMC transport to Moss Landing.

GROSS DIAGNOSES

ADVANCED DECOMPOSITION & MARKED POSTMORTEM SCAVENGING

1.) Uncertain with no trauma: Acutely dead AA M sea otter with no gross evidence of trauma, and abundant SQ, peri-renal and coronary groove adipose (PHOTO) (Based on the stranding period, stranding location & gross presentation, probable DDX include acute domoic acid intoxication +/- systemic *S. neurona*-Limited HP pending)

   -Right kidney & (probable) liver: Moderate diffuse congestion

2.) Aged adult male (Est 11-13) with grizzling at least to chest, and mod/ marked tooth wear, especially caudal molars, but no tooth fractures or grossly infected teeth. Missing central incisors may be a PM artifact (PHOTO)

   -Age was estimated at 7 during capture 3/11/13

<u>INCIDENTAL FINDINGS</u>

1.) No VHF, TDR or PIT tags in carcass (Marked postmortem scavenging through anus with hind limb & pelvic muscles, testicles, spleen, left kidney, omentum, and most of stomach and intestines scavenged postmortem. Tongue, larynx and soft palate and much of cranial skeletal muscle scavenged through mouth)

2.) Ventral midline surgical scar healed and unremarkable

3.) RR flipper: Two flipper tags and additional small round hole in interdigital web flipper hole
   LR flipper: One flipper tag and possible healed flipper tag hole left? (R/O captured and tagged >1 time?-Please see capture records & DSOFS for details)

   -Extra hole on RR flipper was noted during 3/11/13 capture-No clear evidence of prior tagging HX

4.) Likely died in the water:

   -No apparent postmortem myiasis (maggots), and extensively sloughed pelage

5.) All visible lymph nodes WNL

6.) No gross evidence of bacterial sepsis, peritonitis, pyothorax, fungal infection or cardiac vavular endocardiosis or endocarditis

GROSS SUMMARY

This tagged AA M southern sea otter appears to have died acutely with abundant SQ, peri-renal and coronary groove adipose. There is no gross evidence of trauma, or fungal or bacterial infection. All visible lymph nodes are WNL.

There is severe, diffuse autolysis, and marked postmortem scavenging of the abdomen, pelvis and rostral head. No instrumentation (VHF or TDR) was present in the abdomen at gross necropsy, and all skeletal muscle had been scavenged from the hind limbs and peri-pelvic muscle, so PIT scanning was not possible. Lack of visible maggot presence is suggestive of death in the water, with the carcass stranding later during decomposition.

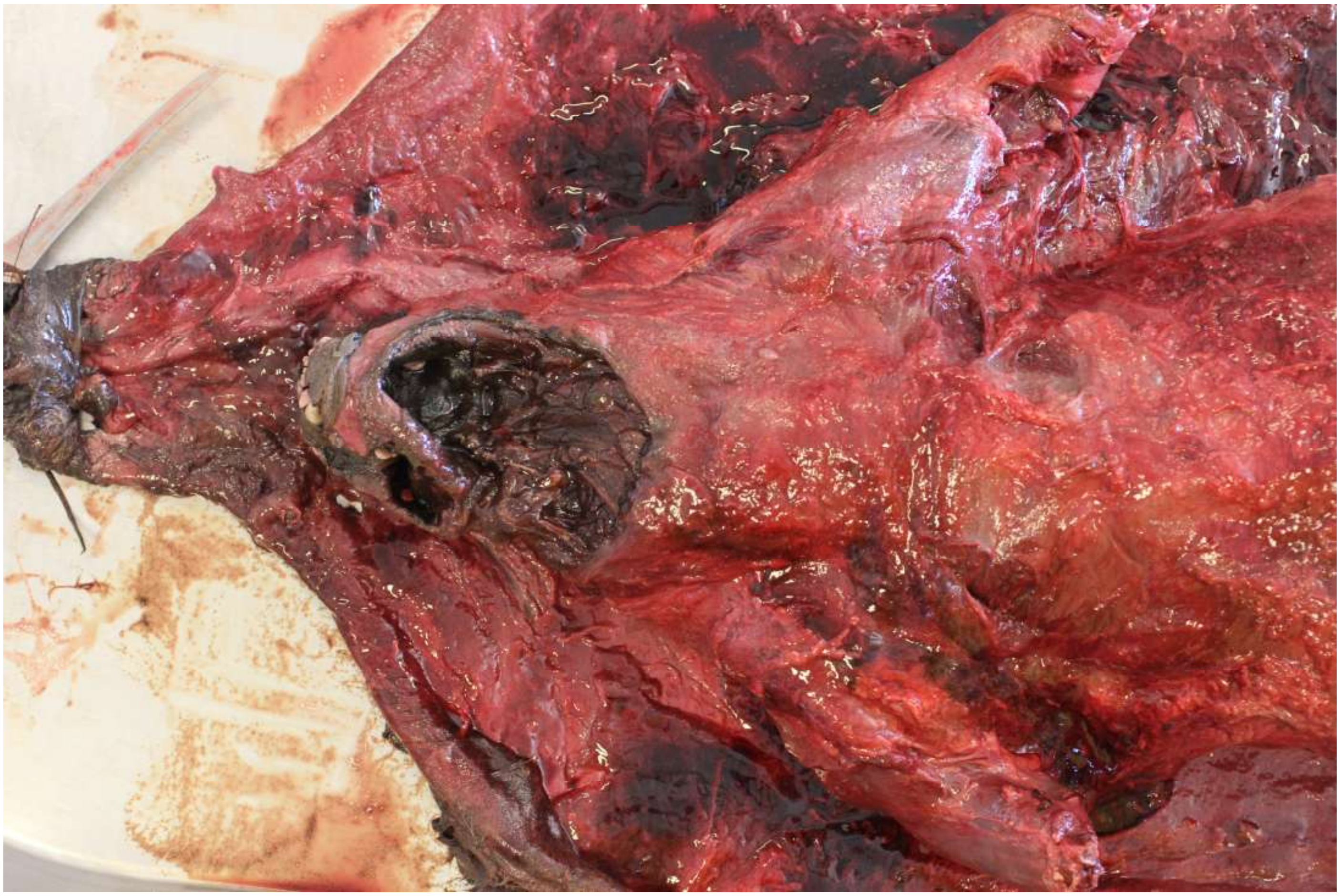
The remaining right kidney is diffusely congested, and the liver may also be congested (hard to be sure due to advanced autolysis). Given the overall case presentation, stranding location and stranding period, acute domoic acid intoxication is suspected. However, it is not possible to confirm this diagnosis due to advanced autolysis and absence of optimal samples for DA testing.

Given this animal's older age, a less likely differential is systemic sarcocystosis. The freshest three pieces of skeletal muscle available (diaphragm, masseter and temporal muscle) will be examined via histopathology for the presence of protozoal sarcocysts.

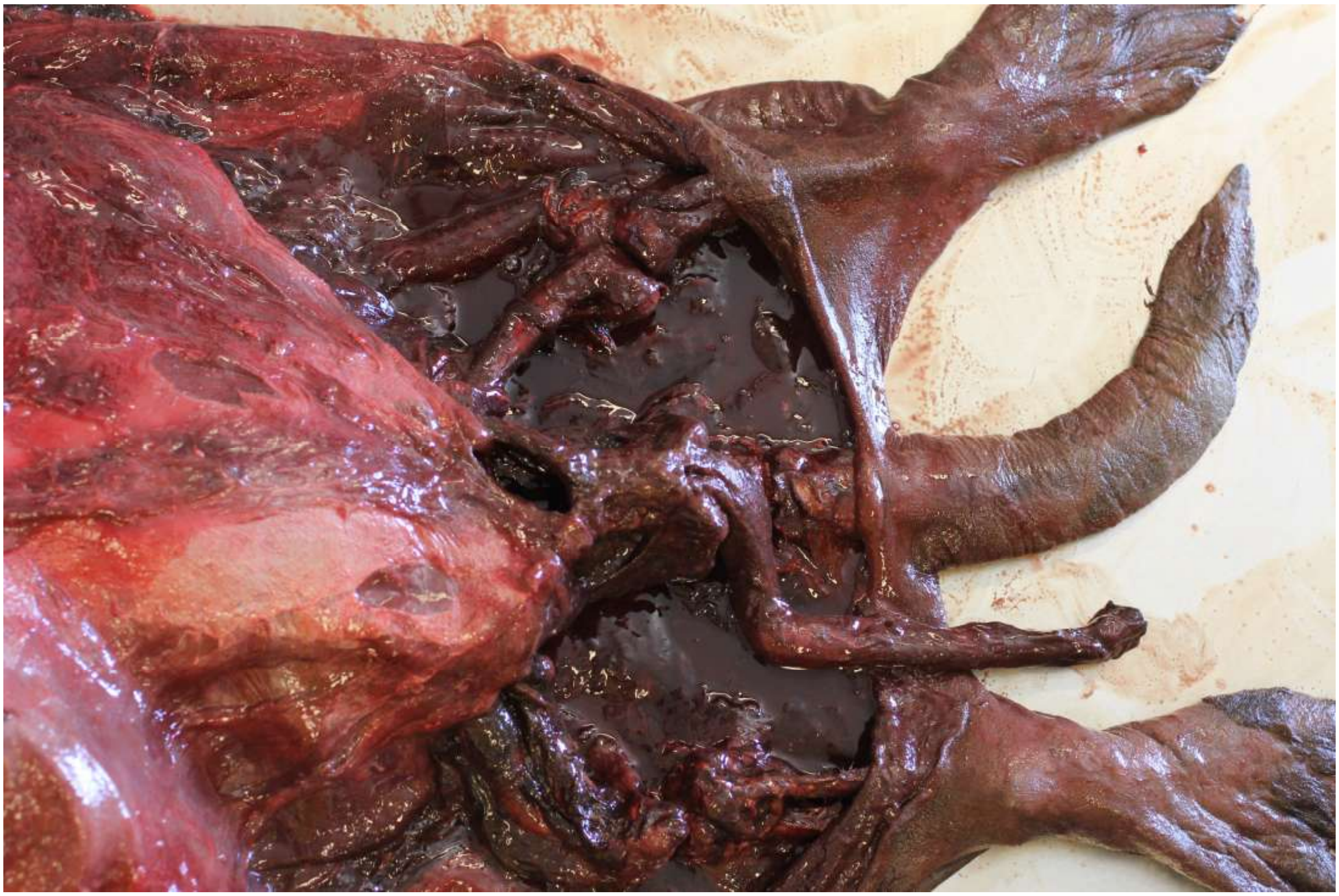
SAVED:
1.) UL premolar
2.) Hair (no whiskers present)
3.) Frozen skeletal MM (for genetics, if desired)
4.) FF masseter & temporal MM, diaphragm for HP (attempt to R/O systemic sarcocystosis)

PENDING:
1.) Muscle HP

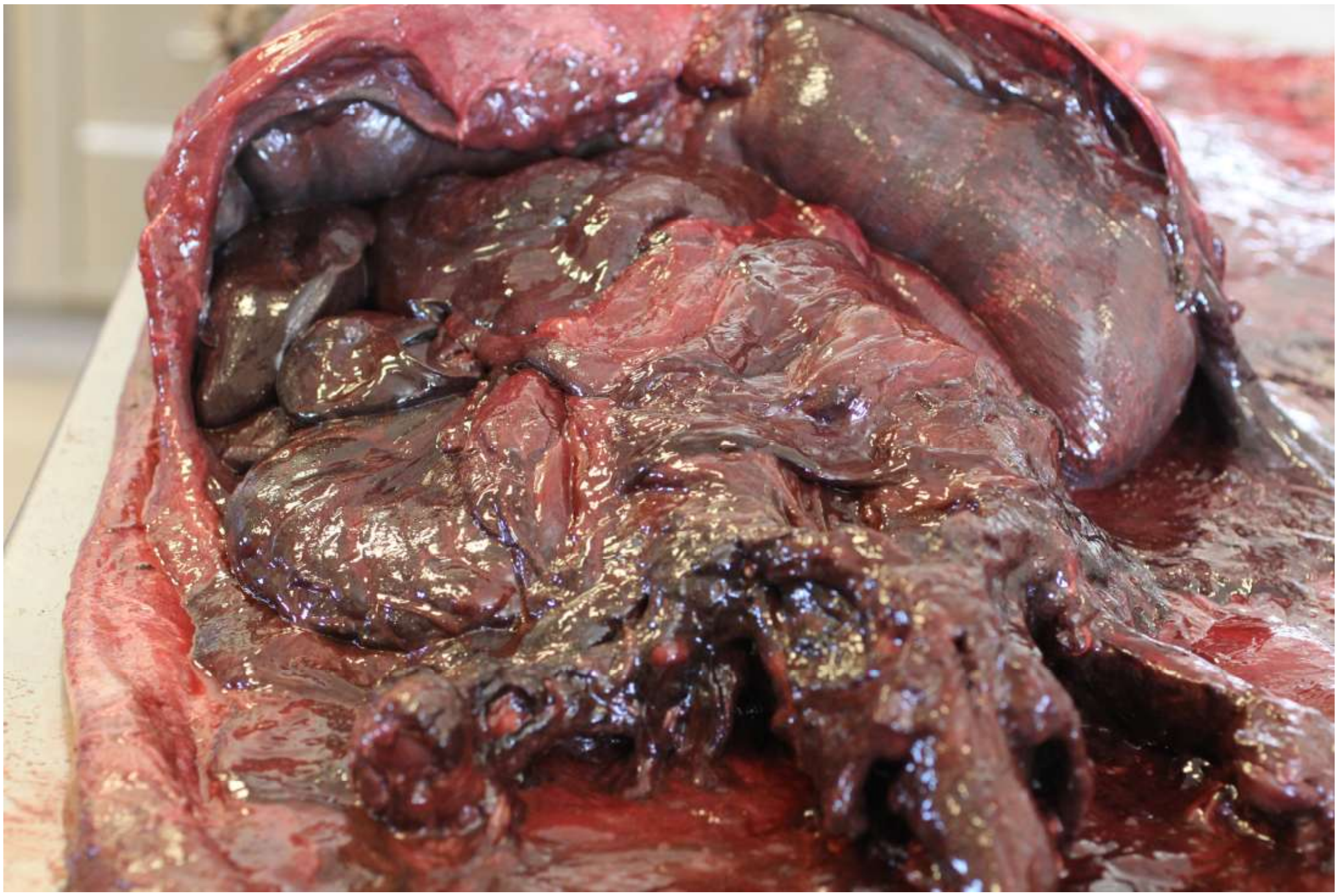
CARCASS ON THE BEACH AT TIME OF RECOVERY



PM SCAVENGING, HEAD



PM SCAVENGING: HIND LIMBS, PELVIS & ABDOMEN



PM SCAVENGING: ABDOMEN (VIEW FROM VENTRAL TAIL)
(DIAPHRAGM IS ARTIFACTUALLY INFLATED WITH GAS FROM DECOMPOSITION)

STRANDED SEA OTTER FACT SHEET

SO# 9004-18

PERSON REQUESTING SO#: HARRIS

DATE FOUND: 31 (DD) JUL (MMM) 2018 (YYYY)

MWVCRC# ~~18-0347~~ 18-0362

FOUND BY: PC RPC BO PM SBS SOB BIO UU — PSLHP

OTHER# BRD 1229-12, 40n N-1507-12-S

RECOVERY AREA: 36 **ATOS:** 894 **LAT / LONG (DD):** N 35.1686 W 120.7537 **TC / GE**

RECOVERY LOCATION: Port San Luis, SLO Co (CITY / COUNTY), Floating East Side Hardford Pier (LOCATION DETAILS, LANDMARKS) **TAR ON BEACH:** N Y / ?

COND: 1=ALIVE (EUTH: Y / N) 2= FRESH 3=MOD DECOMP 4=ADV DECOMP 5=MUMM/FRAG/SKEL 9=? **SCAVENGED:** 0=NO 1= SLIGHT 2=MOD 3=HEAVILY 9=?

SEX: F M / ? **AGE:** 2=PUP 3=IM 4 or 14 =SA 5 or 15 =AD 6=AGED AD 7=PUP OR IM 8=SA, AD, AA 9=?

TAGGED: N Y ? (Y=PG 2) **TAR ON OTTER:** N / Y ? **OBV TRAUMA:** N / Y ? **EST AGE:** 6-7 W / M / YR **BY:** C Young

TL: — CM **TAIL:** 27 tsh CM **WT:** — KG **NOSE WOUND: SIZE:** D **FRESHNESS:** D

TEETH: 5=ALL MILK 6=SOME MILK 1=EXC 2=GOOD 3=FAIR 4=POOR 9=? REMARKS:

ECHINO: 0=NONE 1=SLIGHT 2=OBVIOUS 9=? (SKULL OR PCS EXAMINED, SEE BACK) REMARKS:

GRIZZLE: 6=NATAL 7=JUV BUFF 1=NONE TO SLIGHT 2=TO EYES 3=TO LAMBDOIDAL CREST 4=TO CHEST 5=TO TAIL 9=?

RED ALGAE ON FUR: N / Y ? VISUAL / UV LAMP 1=< 2% 2=2-10% 3=11-20% 4=>20% REMARKS:

NECROPSY: NO F G / D BY WHOM: B BP / V / VP / P F Batac, C Young DATE: 09 Aug 2018

COND AT NEC: 2 / 3 / 4 / 5 **PREV FROZEN:** N Y **LOCATION OF NECROPSY:** MWVCRC

SUBCU FAT: 0=NONE 1=SCANT 2=FAIR 3=MOD 4=ABUND 9=? *some present but can't assess amt. **TARRY DIGESTA:** 0=NOT OBVIOUS 1=SLIGHT 2=OBVIOUS 9=?

FOOD IN GUT: 0=EMPTY 1=LITTLE 2=MED 3=FULL 9=? PREY: hard shell parts (clam?)

ACANTH: UNK / NO / C / P / C=P / CP / PC INT: 0=NONE 1=MILD 2=MOD 3=HEAVY 9=? AB: 0=NONE 1=MILD 2=MOD 3=HEAVY 9=?

FETUS: N=NO Y=YES, NO SEX M=YES, MALE F=YES, FEMALE U=? TL: — CM CR: — CM WT: — GM

WOUNDS CHARC OF SHARK BITE: N / Y / ? **EFFORT TO CONFIRM:** 0=NONE 1=CURSORY 2=INTENSIVE 3= NA

WOUND DESCR: 1= NO OBVIOUS HEALING 2= INDICATION OF HEALING 3= INDICATION OF INFECTION 4= OBVIOUSLY OLD, HEALED 5= ? 6=NA

EVIDENCE WOUNDS ANTE-MORTEM: Y / ? NA IF YES: SQ HEM OTHER:

REMARKS:

Tag hole (R 1/2) found and VHF palpated at necropsy No PIT tag detected
↳ PIT tag found, was no detected by scanner

Surgical scar unremarkable

VHF free-floating (164.955)

TDR ~~entrap~~ wrapped in omentum #1290722) but not entrapped

Regressing mammary tissue

PREMOLAR: N / UR UL LR LL ~~missing~~/already taken **FUR:** N Y **WHISKERS:** N Y **OTHER SAMPLES:** N / Y (Y=SEE BACK) **PHOTOS:** N Y

CAUSE OF STRANDING: 1 (unknown) **IF CODE=10 OR 11, THEN PRIMARY:**

OTHER SIGNIFICANT FINDINGS:

DISPOSITION: CARCASS: ~~80~~ **PELT:** Ø **SKELETON:** Ø **SKULL:** 192 ~~Ø~~ ↳ CAS15 **BACULUM:** Ø **PREMOLAR:** 192 ~~Ø~~

~~FROZEN~~ to ~~MWVCRC~~ 2 AUG

CONTINUE ON BACK: N / Y

JH 8/15/18

FACTSHEET2016_V1

R LG 1/2, L TQ 1/2
BRD 1229-12
UON N-1507-12-S
PIT SLO 2012025
Captured 05 OCT, 2012, PT BUCHON

- Last pregnancy on R horn (placental band present)
- No gastric erosions
- Fat on kidneys/heart
- No sand in trachea
- Heart valves look normal

- X-rays not taken

CDFW SEA OTTER NECROPSY REPORT

California Department of Fish and Wildlife
Office of Spill Prevention and Response
Marine Wildlife Veterinary Care and Research Center
151 McAllister Way
Santa Cruz, CA 95060
(831) 469-1719

Sea Otter:	9018-18
UCD PATH:	18s0587
MWVCRC Necropsy	18-0410
Report Date:	8/13/2018
Report Status:	Gross

CASE PROFILE

DFG/BRD#:	1375	**Report By:**	**Miller**
UON#:	N-1651-17-S	**Necropsy By:**	Miller, Dodd, Batac, Young
MBA#:		**Necropsy Date:**	8/13/2018
Date Found:	8/10/2018	**Condition:**	Mod Decomp
Condition Found:	Mod Decom	**Sex:**	Female
Live Strand:	No	**Age Class:**	Adult
Euthanized:	No	**Estimated Age:**	7-9 by M. Miller
Date Died:		**Location:**	Seaside Beach
Total Length (cm):	119	**County:**	Monterey
Weight (kg):		**ATOS:**	366
Nutritional State:	Emaciated	**DSOFS COD:**	11P
SQ Fat:	Scant	**Histopathology:**	Full
Food in Gut:	Unknown		

MORTALITY DATABASE CODING

Primary COD Possible DA intoxication

Sequela 1 Possible perimortem seawater aspiration

Secondary COD Possible ELS

Tertiary COD Gastric erosions and melena

Quaternary COD Marked tooth wear

CASE BACKGROUND

Captured at Otter Point on 9/27/17, 18.8 kg, 115.5 cm, estimated at 10 or 11 years old by Marissa Young, and not palpably pregnant.

NSF study animal captured 27 Sept. 2017. Was last heard 7 Aug 2018 at Point Pinos. Last seen 30 July 2018 at Otter Point with large pup (25.4 weeks). Had been seen resting with constant tremor on right hind limb since 20 May 2018. Has VHF transmitter, but no TDR. Diet predominantly mussels and urchins.

Per Jessica Fujii

GROSS DIAGNOSES

Moderately decomposed

1. Possible domoic acid intoxication (Pending histopathology)

-Hx chronic right hind limb tremor
-Moderate to marked vascular congestion of meninges, and possible moderate diffuse brain swelling
-Abundant reddish fluid around nose and mouth

1a. Possible perimortem seawater aspiration:
-Lungs dark red-black and wet (scant septal edema)
-Serous pleural effusion (est. approx. 150 ml)
-Approx. 7 ml of red-tinged pericardial fluid

2. Possible ELS (Pending histopathology)

-Estimated as adult female at necropsy (7-9 years) (Assessed as aged adult during captures 1 year previously)
-Was observed alive with large pup (25.4 weeks) 14 days prior to carcass recovery as a moderate decomp
-Thin animal with moderate symmetrical muscle atrophy and scant SQ adipose, but moderate omental and mild peri-renal adipose. No coronary adipose (animal seems a bit "out of cycle for a classical ELS case: Review HP and repro staging, and R/O forced copulation of animal with CNS Dz if possible)
-Reproductive stage 5 (pending HP)
-Moderate (~4-5 mm thick) pink mammary tissue and large nipples, not lactating
-Large pink/red nose wound
-Ovaries: 2+ CAs, 2+ follicles or early CLs (pending HP), no paraovarian cysts
-Uterine horns small and symmetrical (partially scavenged)
-Vulva not apparent due to PM scavenging

3. Gastric erosions, body and pylorus and melena

4. Marked tooth wear

5. Marked diffuse bilateral adrenal cortical hypertrophy

INCIDENTAL FINDINGS:

1. VHF transmitter possibly free-floating (abdomen partially scavenged), no TDR

2. Small fibrous adhesion/fibrous band running from hepatic quadrate lobe to ventral aspect of ventral midline abdominal incision. Sx incision otherwise unremarkable

3. Abdomen, pelvis and both eyes scavenged postmortem: Missing both eyes, bladder, part of uterus, spleen and omentum, and most of intestines)(except duodenum). VHF transmitter lodged inside of pelvis at necropsy

4. Intestinal Corynosoma (parasite load unknown due to PM scavenging of most of intestines)

GROSS SUMMARY

Findings from gross necropsy were not definitive, so further assessment will be performed via histopathology. Possible differentials for the cause of death include DA intoxication and ELS. Mating-associated drowning is a less likely possibility.

Saved:

Most tissues saved for HP (except eyes, intestine, bladder, mammary tissue)
Frozen: Pericardial fluid, whole blood, brain, lung, liver, kidney, spleen, stomach, bile, lymph nodes, tongue, heart muscle,
Caudal limbs and pelvic bones saved for comparison with bones from boat strike cases

CDFW SEA OTTER NECROPSY FINAL REPORT

California Department of Fish and Wildlife
Office of Spill Prevention and Response
Marine Wildlife Veterinary Care and Research Center
151 McAllister Way
Santa Cruz, CA 95060
(831) 469-1719

Sea Otter:	9071-18
UCD PATH:	18S0769
MWVCRC Necropsy	18-0463
Report Date:	11/19/2018
Report Status:	Final

CASE PROFILE

DFG/BRD#:	1361	**Report By:**	C. Young, F. Batac, M. Miller
UON#:	N-1637-16-S	**Necropsy By:**	F. Batac, C. Young, K. Greenwald, E. Dodd
MBA#:		**Necropsy Date:**	10/5/2018
Date Found:	10/4/2018	**Condition:**	Adv Decomp
Condition Found:	Mod Decom	**Sex:**	Female
Live Strand:	No	**Age Class:**	Adult
Euthanized:	No	**Estimated Age:**	6
Date Died:		**Location:**	Stillwater Cove (recovered from water)
Total Length (cm):	115	**County:**	Monterey
Weight (kg):	23.5	**ATOS:**	421
Nutritional State:	Good	**DSOFS COD:**	9
SQ Fat:	Moderate	**Histopathology:**	Partial
Food in Gut:	Full		

MORTALITY DATABASE CODING

Primary COD: Research-related death

Sequela 1: Severe omental “boloing” (torsion)

Sequela 2: Omental infarction and intestinal entrapment

Sequela 3: Serofibrinous peritonitis and effusion

Sequela 4: Possible sepsis

Secondary COD: Cardiomyopathy/DCM, mild/mod

Tertiary COD: None

Quaternary COD: None

CASE BACKGROUND

Captured once on 6/2/2016 at Otter Point, 14.4 kg, 110 cm, TDR 1690069, VHF 167.792, PIT 985141000930644.

M. Staedler 04Oct2018:

Sea Otter “Colleen” BRD # 1361-16; UON N-1636-16-S

Last visual was on 9/26 with a 13.71 week old pup. Two radio re-sights were done after that date, one on 9/27 and the other on 9/29. She is usually seen at Carmel Beach, Stillwater Cove area or Pescadero Point. Diet consists of mussels, crabs, snails.

This was her second pup that we know of, her previous one being in 2016 which did not survive; she lost it after a month. We estimated her to be fairly young at captures; 3 years of age

On another note, she was captured at Otter Point, in the summer, but left the area to “head south” in the fall, returning briefly for a few re-sights in November in Otter Point, back south, only to return to Otter Point in May/June of 2017 where she continued to go back and forth between these two general areas

FINAL DIAGNOSES

Advanced decomposition at necropsy

1) Post-surgical TDR extrusion from falciform ligament, with subsequent fibrous omental-falciform adhesion, and omental entrapment of both TDR and VHF transmitter inside omental bursa (PHOTO)
- Omentum was attached to the falciform ligament cranial to the surgical incision (Post-surgical adhesion secondary to TDR extrusion into abdomen, pres.) (PHOTO)
- Ventral midline surgical incision grossly unremarkable with no apparent adhesions

1a.) Severe omental “boloing” (torsion) secondary to both TDR and VHF entrapment inside omental bursa, forming two separate, tightly intertwined “bolos” (PHOTO)
- Omental stalk associated with VHF entrapment very tightly twisted, with three 360 full turns (1,080 degree omental torsion) (PHOTO)
- Omental torsion associated with TDR entrapment located further down the resulting omental stalk and more loosely twisted than the VHF

1b.) Severe omental infarction (gross diagnosis), and severe multifocal intestinal entrapment and impaction by torsed omentum, with marked venous engorgement of effected mesenteric blood vessels, and marked peri-intestinal perivascular mesenteric edema, char by:
- Omentum associated with areas of instrument entrapment and twisting is brownish-red and markedly friable (PHOTO)
- TDR, VHF, omentum, and intestinal loops tightly entangled at multiple locations (PHOTO)
- Tightly twisted omental stalk wrapped around small and large intestine in at least two locations, with secondary severe serosal pallor, luminal constriction, and segmental proximal intestinal impaction of ingested prey (purple urchin, snail, mussel, crab)
- Mesentery adjacent to areas of intestinal constriction/impaction dark reddish-black (venous congestion), with focally severe segmental perivascular edema (PHOTOS)

1c.) Marked serofibrinous omentitis, peritonitis and effusion (PHOTO)
- Marked serofibrinous peritoneal effusion with abdominal dilation and prominent fluid wave (PHOTO)
- Peritoneum and mesentery: Multifocal fibrin tags +/- possible fibroplasia (PHOTO)
- Moderate to marked mesenteric lymphadenopathy (PHOTO)
- No intestinal acanthocephalans, and no grossly visible peritoneal acanthocephalans
- No microscopic evidence of prior/resolving acanthocephalan peritonitis

1d.) Possible perimortem bacterial sepsis, char. by:
- Moderately enlarged spleen

2) Mild/moderate cardiomyopathy (and suspect DCM), char. by:
- Mild/moderate diffuse myocardial pallor (PHOTO)
- Moderate/marked bilateral cardiac dilation with prominent double apex (PHOTO)
- Mild/moderate myofiber loss and stromal fibrosis (most severe in LVFW, IVS, apex & left ventricular papillary muscle)
-No clear evidence of congestive heart failure on histopathology, but advanced autolysis precluded precise assessment

INCIDENTAL FINDINGS:
1) Prominent perivulvar tangles (Possible forced perimortem out-of-cycle copulation of non-estrus female secondary to severe illness) (PHOTO)
- Reproductive stage: Early stage 4 (mid pup care period, pres.), char. by:
- Abundant thick, dark pink mammary tissue with slight lactation (PHOTO)
- Left ovary: 1 CA, 1 paraovarian cyst
- Right ovary: 1-2 CAs
- Uterine horns symmetrical, placental bands left and right, most recent pregnancy on left horn
- Nose wound: Unknown due to postmortem decomposition (PHOTO)
- Moderate nutritional condition, char. by moderate SQ and coronary adipose

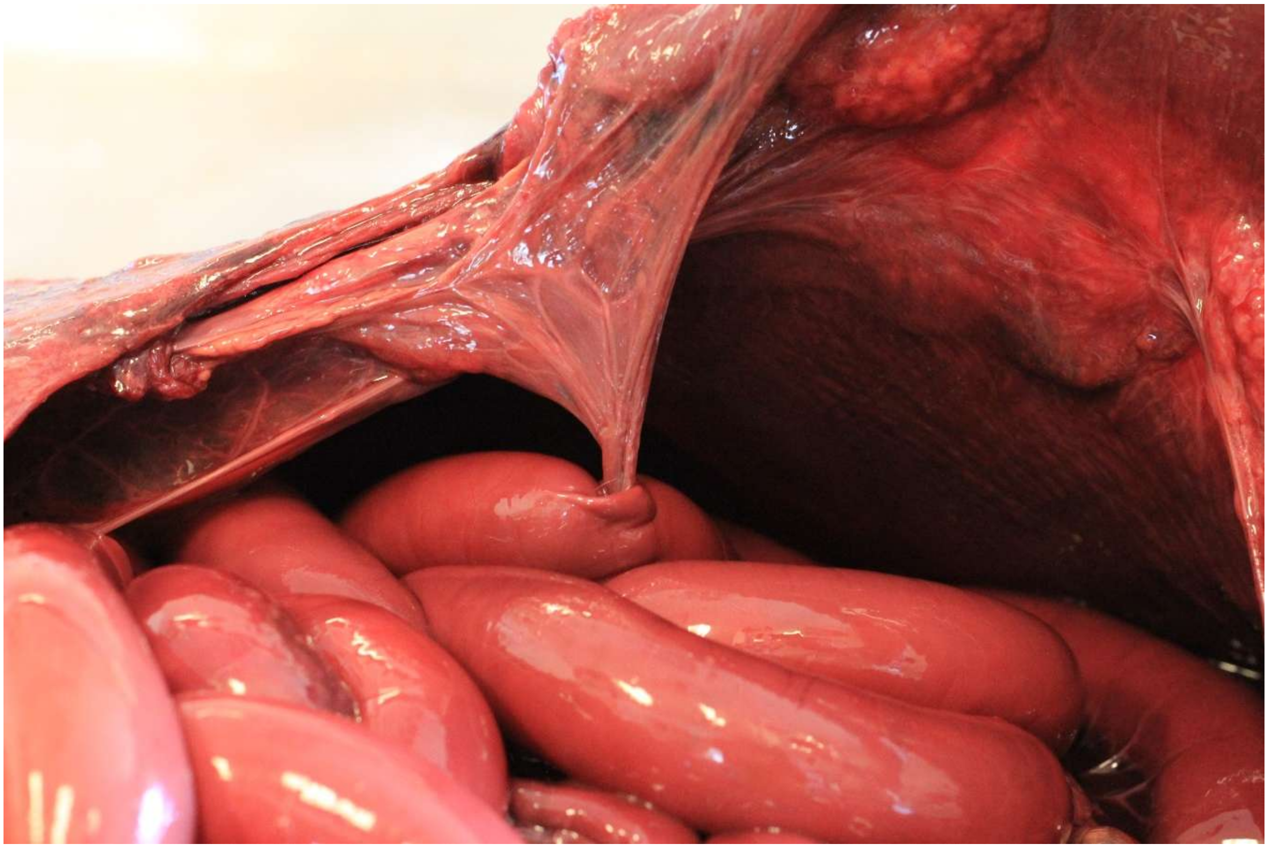
2) Patchy wet and partially sloughing pelage (PHOTO)
3) Mild nasopulmonary acariasis, nasal cavity
4) Possible accessory spleens in omentum (Possible prior non-fatal splenic trauma?)-No accessory spleens observed on HP
5) Mitral and aortic valve WNL, foramen ovale closed
6) Probable mature protozoal tissue cyst (sarcocyst), myocardial LVFW near papillary MM (PHOTO)

COMMENT

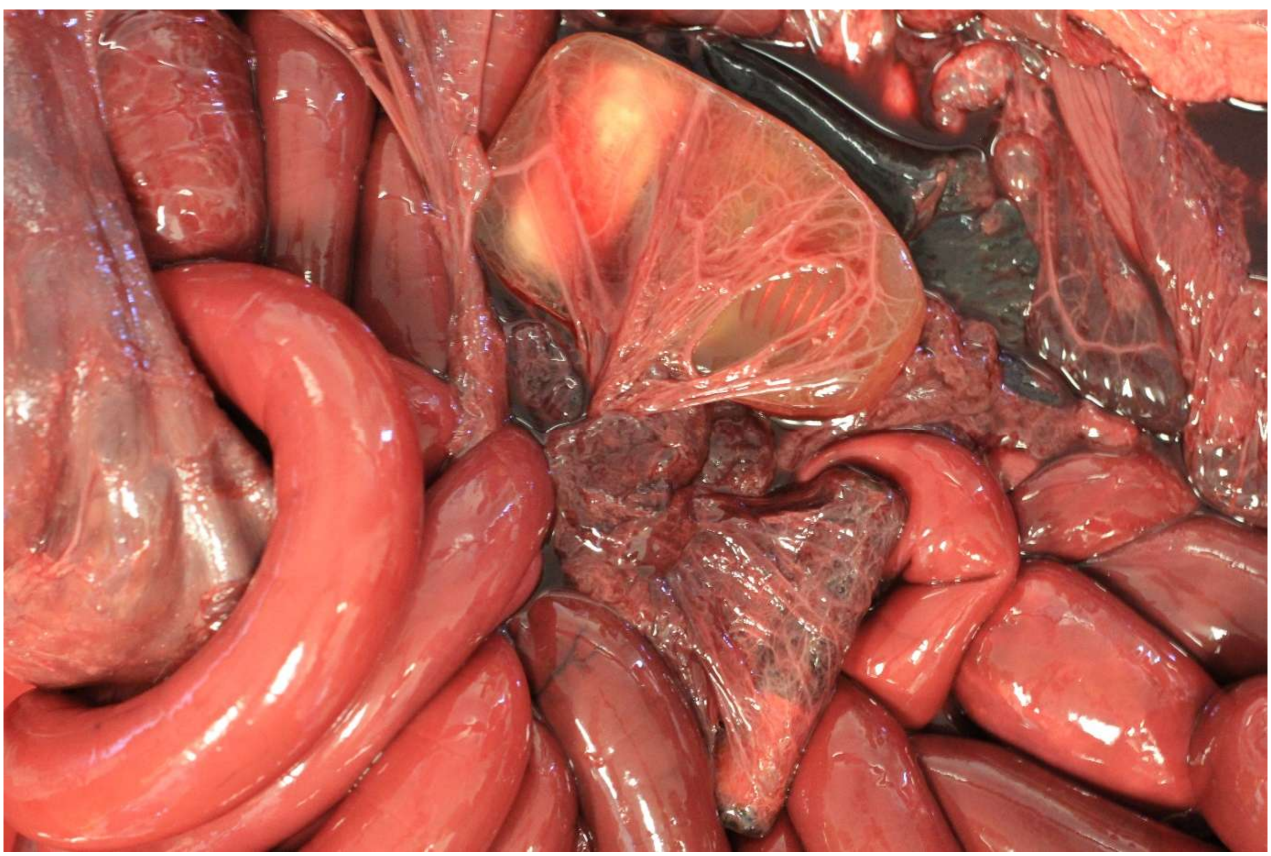
Findings from gross necropsy and histopathology are strongly suggestive of death due to complications of omental entrapment of a surgically-placed TDR and VHF transmitter. Although the TDR had been surgically placed inside of the falciform ligament, it was found inside of the omental bursa at necropsy. A small fibrous adhesion of the omentum to the falciform ligament is supportive of post-operative TDR extrusion into the peritoneum. No adhesions were apparent at the midline surgical incision. Over time, both instruments passed into the omental bursa, and then moved to the outer edge of this sac-like tissue at different locations. The weight of these instruments at the outer portion of the omentum contributed to progressive torsion/twisting of adjacent omentum (e.g. “boloing”) into two separate, but intertwined tissue stalks, each containing an instrument (e.g. VHF or TDR) at the outer edge. The stalk associated with the VHF transmitter was especially long and tightly twisted. Multifocal instrument entrapment and subsequent torsion contributed to severe omental infarction and multifocal intestinal entrapment by the heavily weighted, twisted and freely moveable omental “bolos”, with contributing impacts by the omental-falciform adhesion.

Segments of entrapped small and large intestine developed progressive proximal intestinal impaction and mural vascular compromise, leading to segmental mesenteric edema. Omental, intestinal and mesenteric compromise contributed to the development of serofibrinous peritonitis, and possibly, perimortem sepsis. Moderate to severe omentitis was confirmed in multiple sections of omentum on histopathology, including the brown, friable portions associated with the instrument entrapments. Marked mesenteric venous congestion, and possible marked intestinal mucosal congestion, and mesenteric edema and hemorrhage were also noted on histopathology. The extent of antemortem omental or intestinal infarction could not be accurately assessed due to severe postmortem autolysis. Marked postmortem bacterial proliferation also obscured the ability to confirm antemortem bacterial peritonitis. No gross or microscopic evidence of acanthocephalan peritonitis was found in multiple sections of intestine, mesentery or omentum at necropsy or via histopathology. This animal died in good nutritional condition, suggesting that although the sequence of events leading to death took some time to develop, the final steps progressed relatively rapidly.

Mild/moderate cardiomyopathy was confirmed on histopathology. There was no clear evidence of congestive heart failure, but advanced autolysis precluded precise assessment. The area of red-black discoloration that was noted grossly along the coronary groove (PHOTO) appeared to be an area of peri/ PM fluid leakage +/- serous atrophy of coronary adipose on HP.

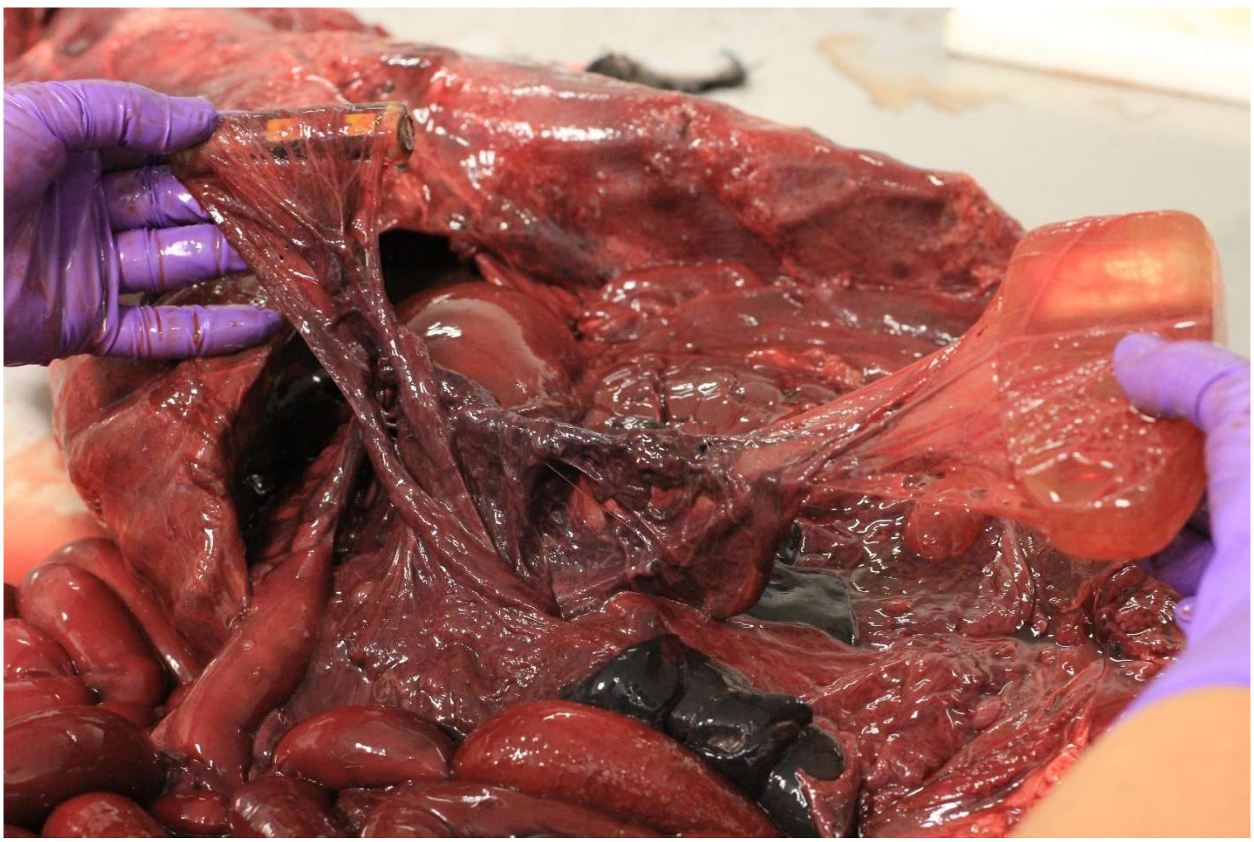


Fibrous adhesion connecting the omentum to the falciform ligament

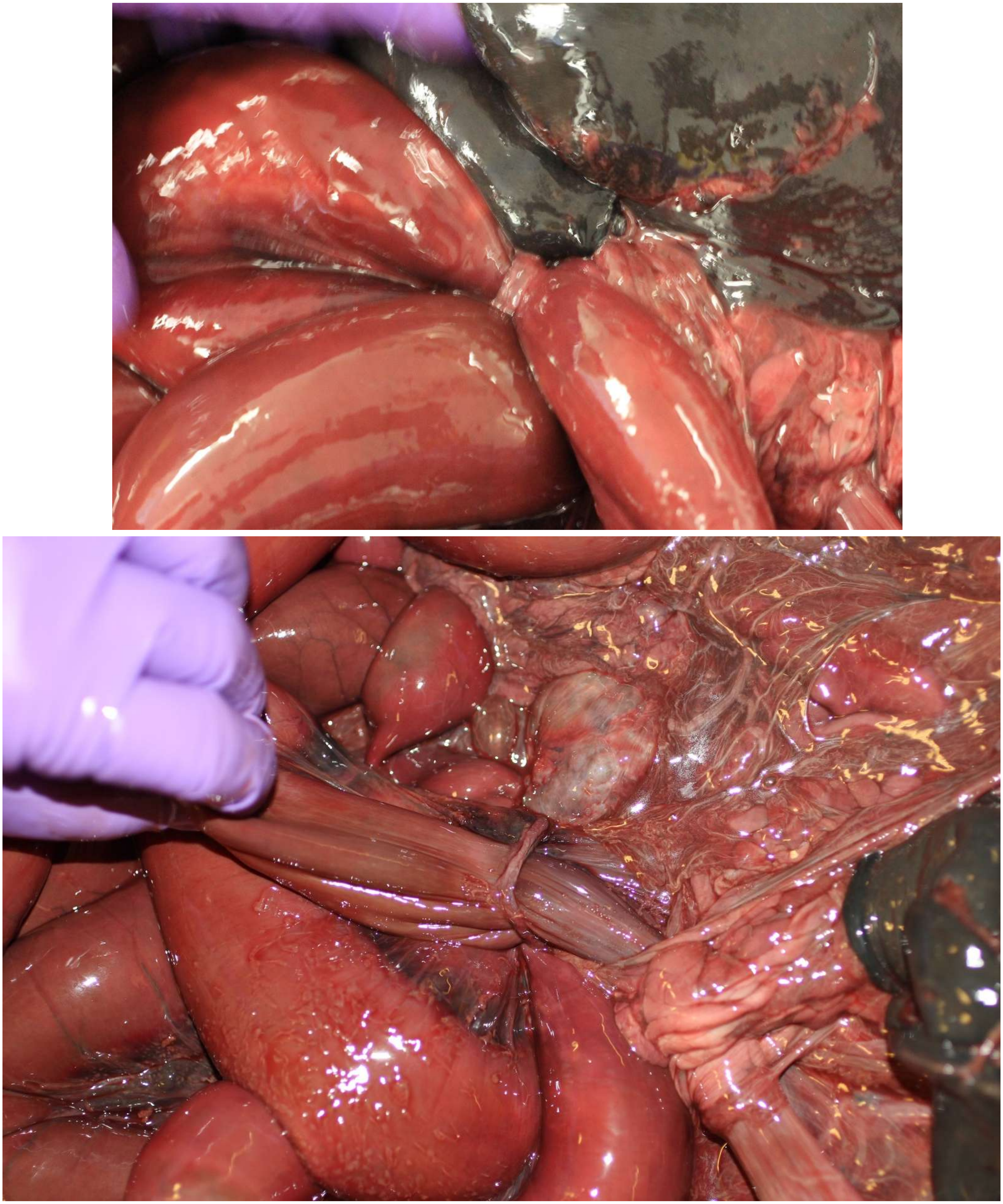


TDR and VHF entrapped in the omental bursa with subsequent twisting and “bolo” formation

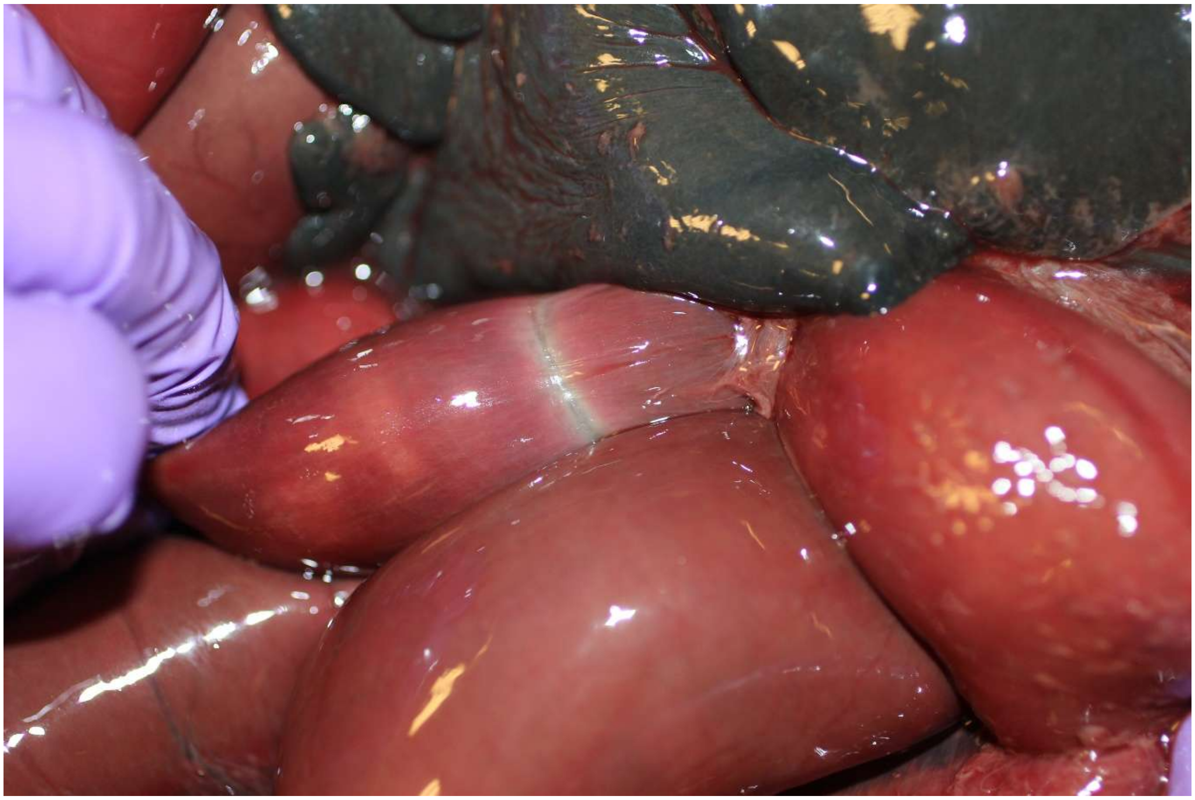
The omentum below the VHF transmitter was tightly twisted into a long stalk

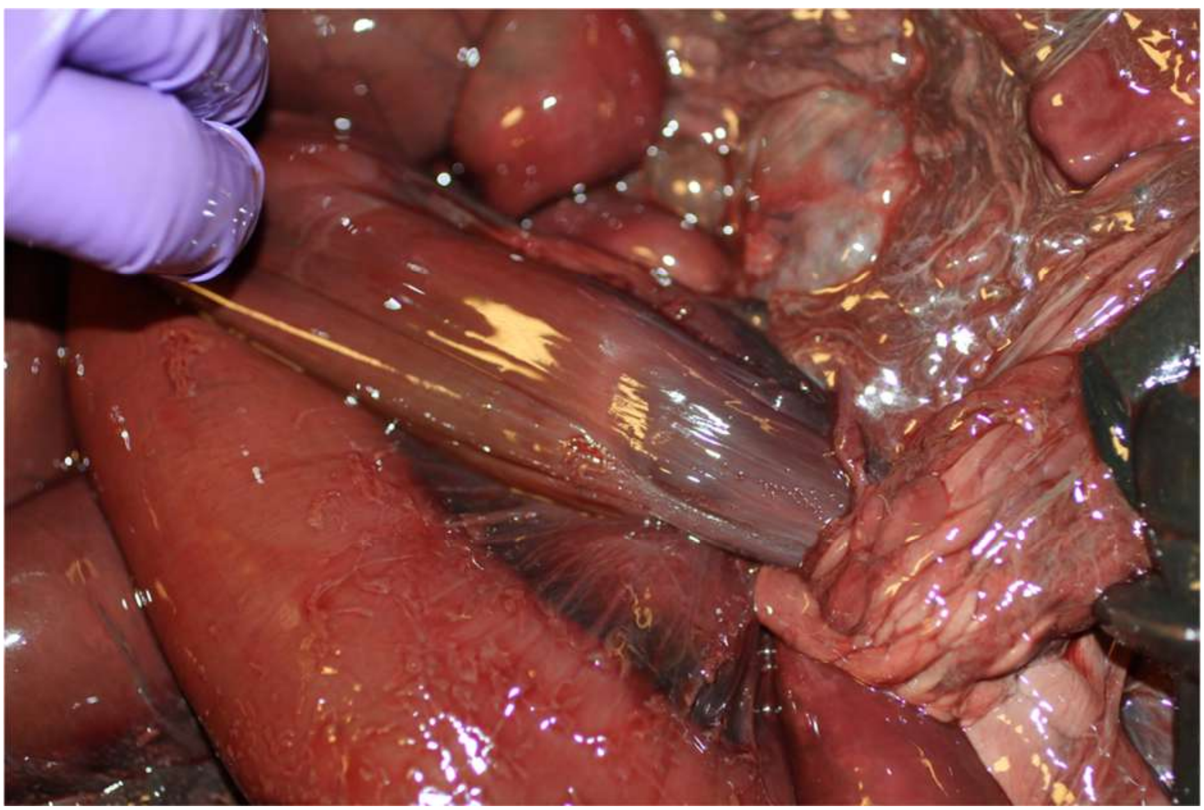


The omentum at the base of the VHF and TDR-associated omental twists was dark brownish-red and friable (omental necrosis, pres.)

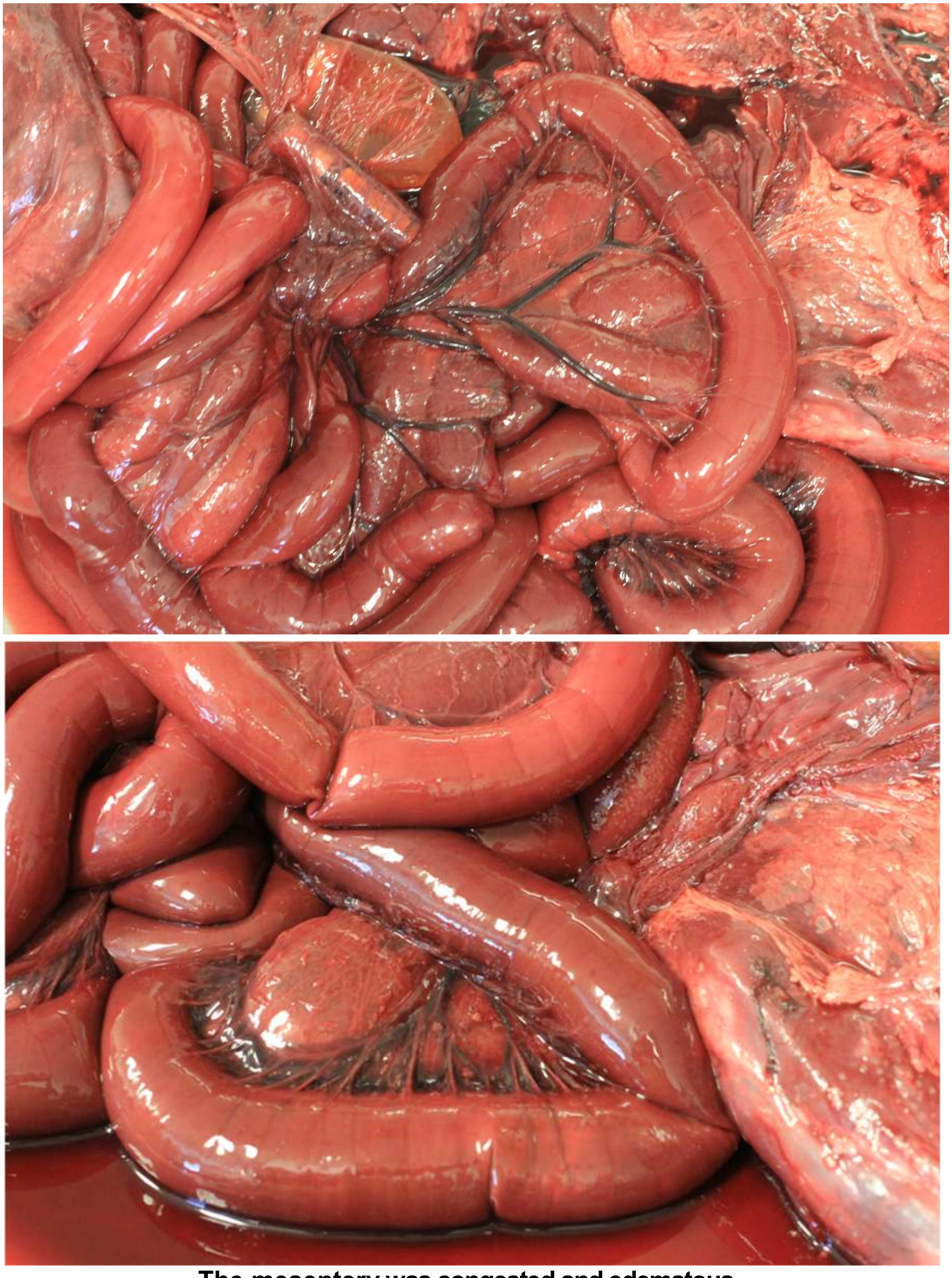


Two different (small and large intestinal, respectively) sites of intestinal constriction and proximal intestinal impaction following omental entrapment.

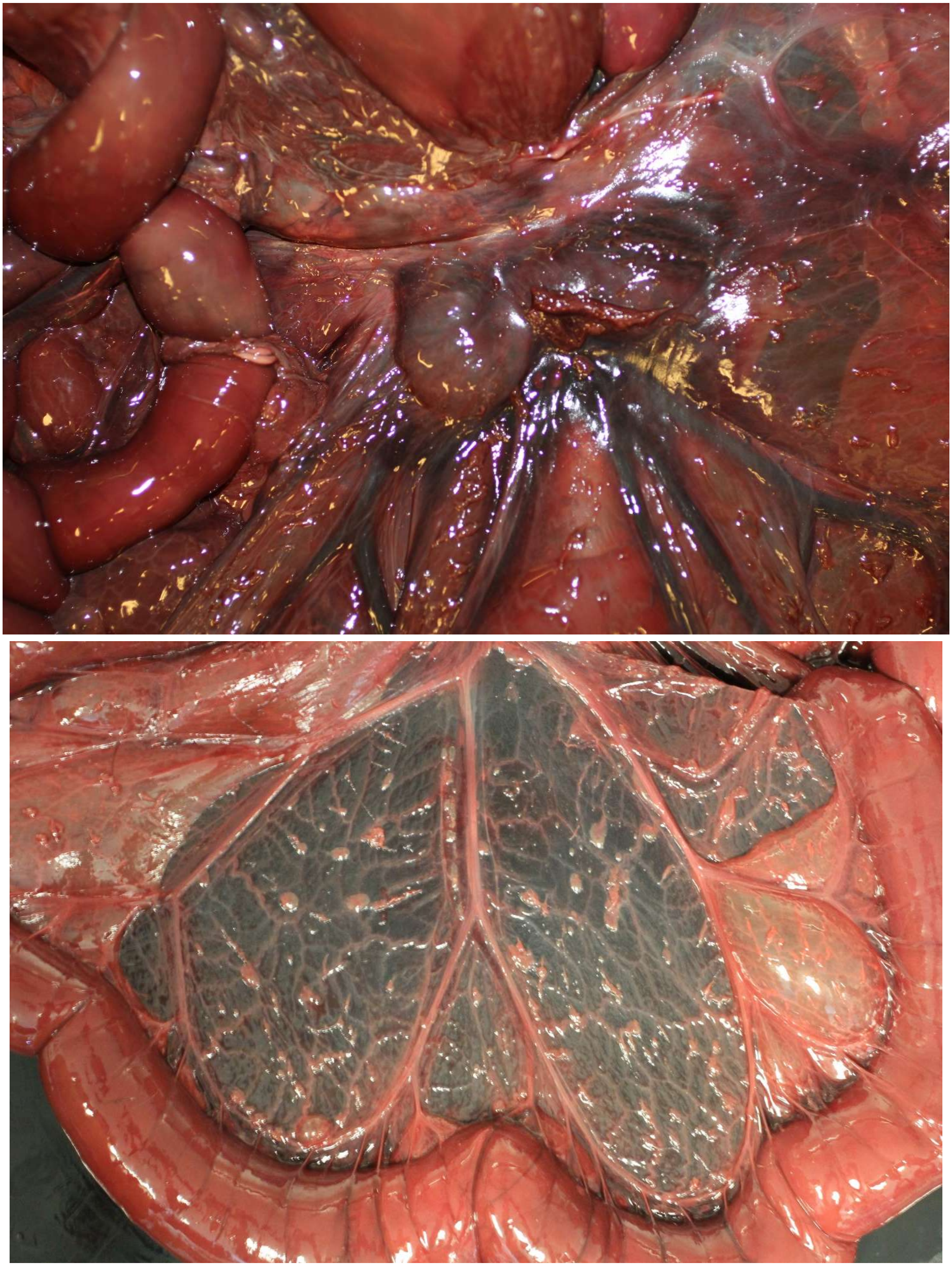




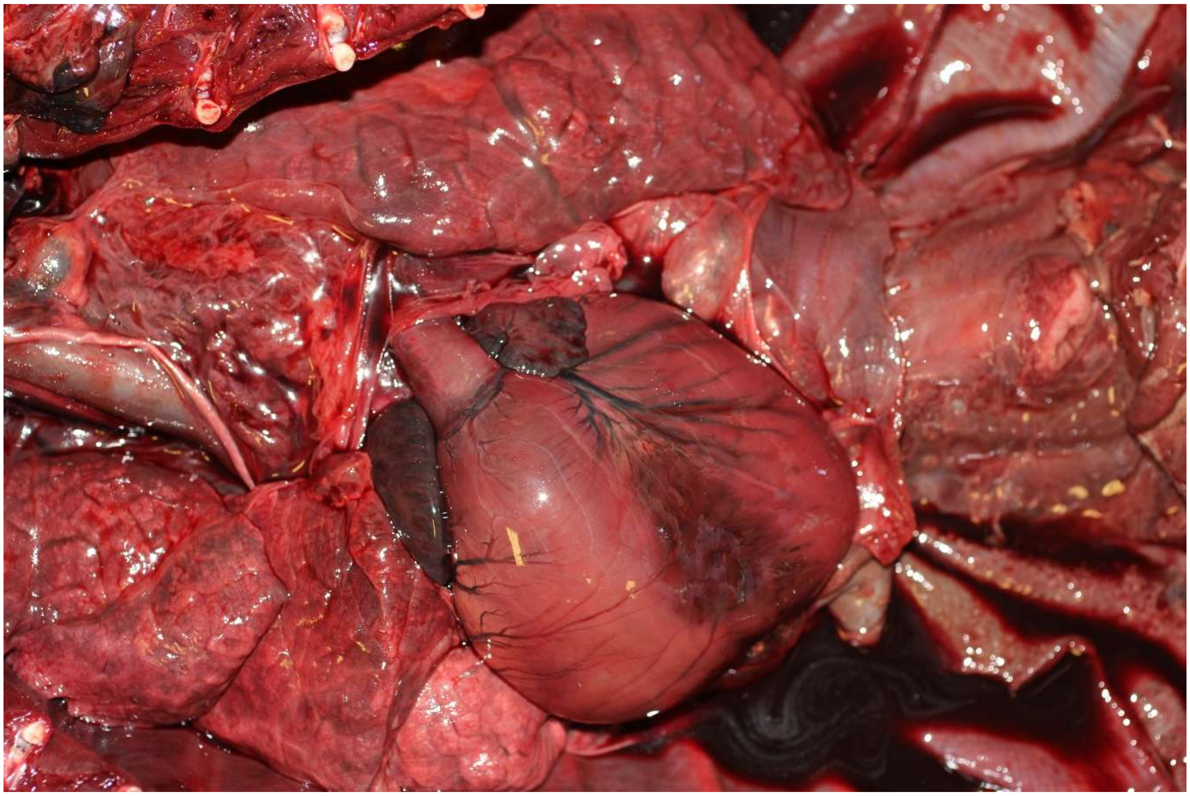
Minimal to marked serosal pallor and luminal constriction was apparent after the omental bands were removed. Also note perilesional serosal fibrin tags in lower photo.

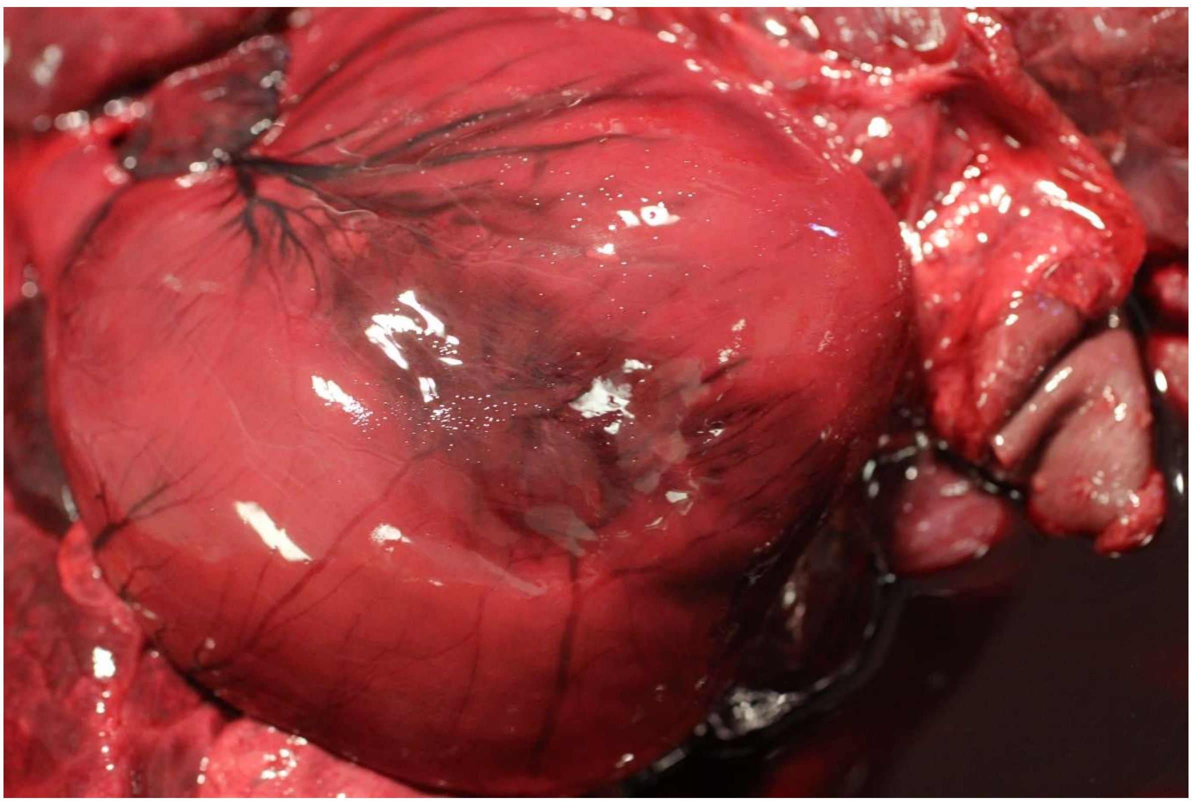


The mesentery was congested and edematous proximal to regions of intestinal constriction/impaction

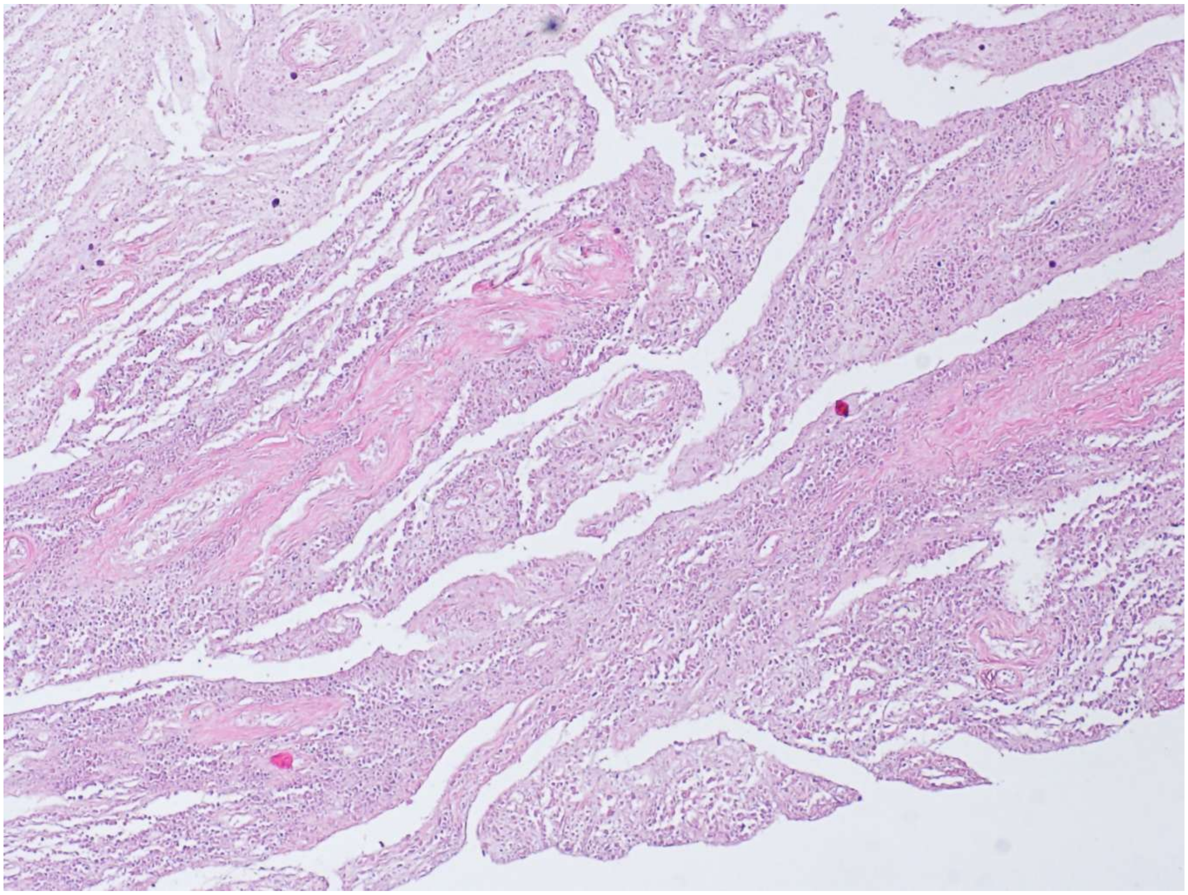


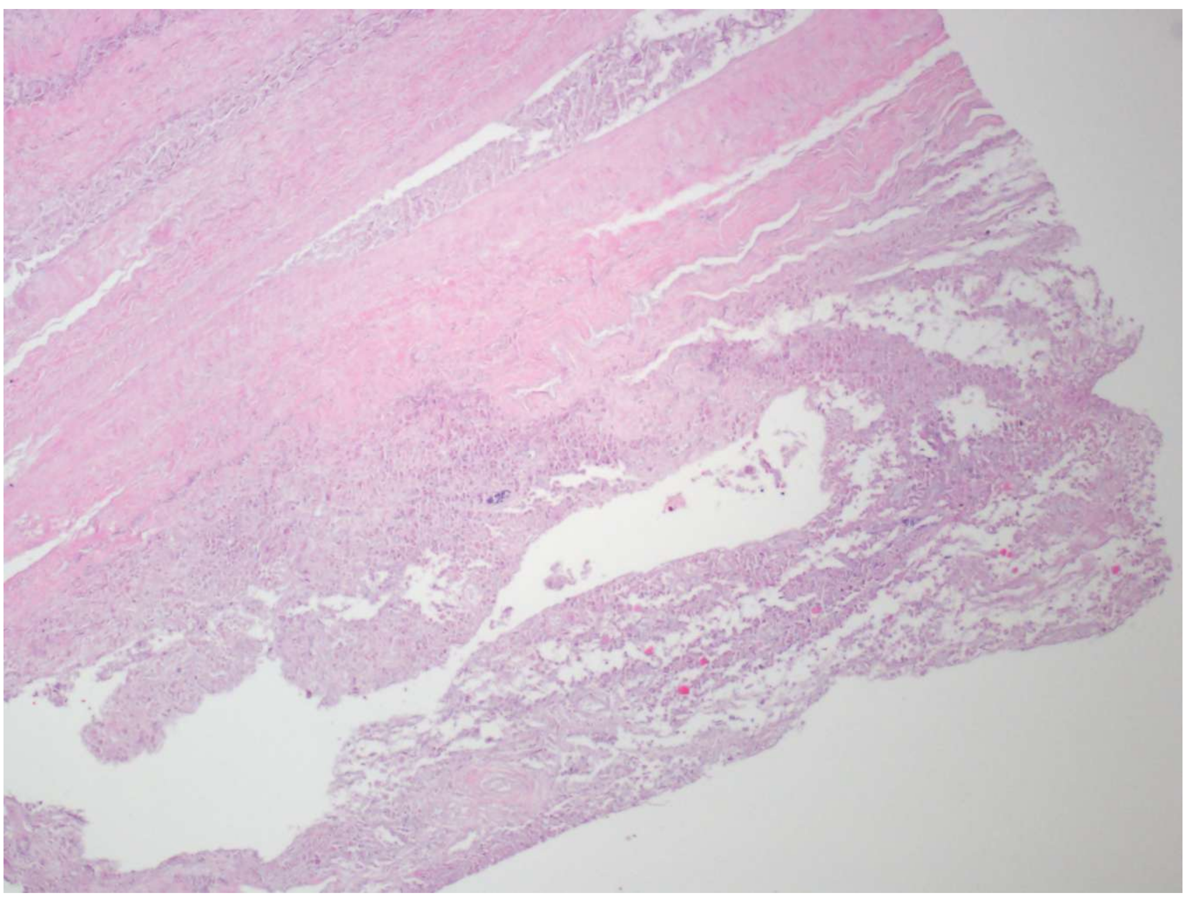
Free-floating masses of fibrin (above) and adherent fibrin tags (below) were apparent in the affected areas.



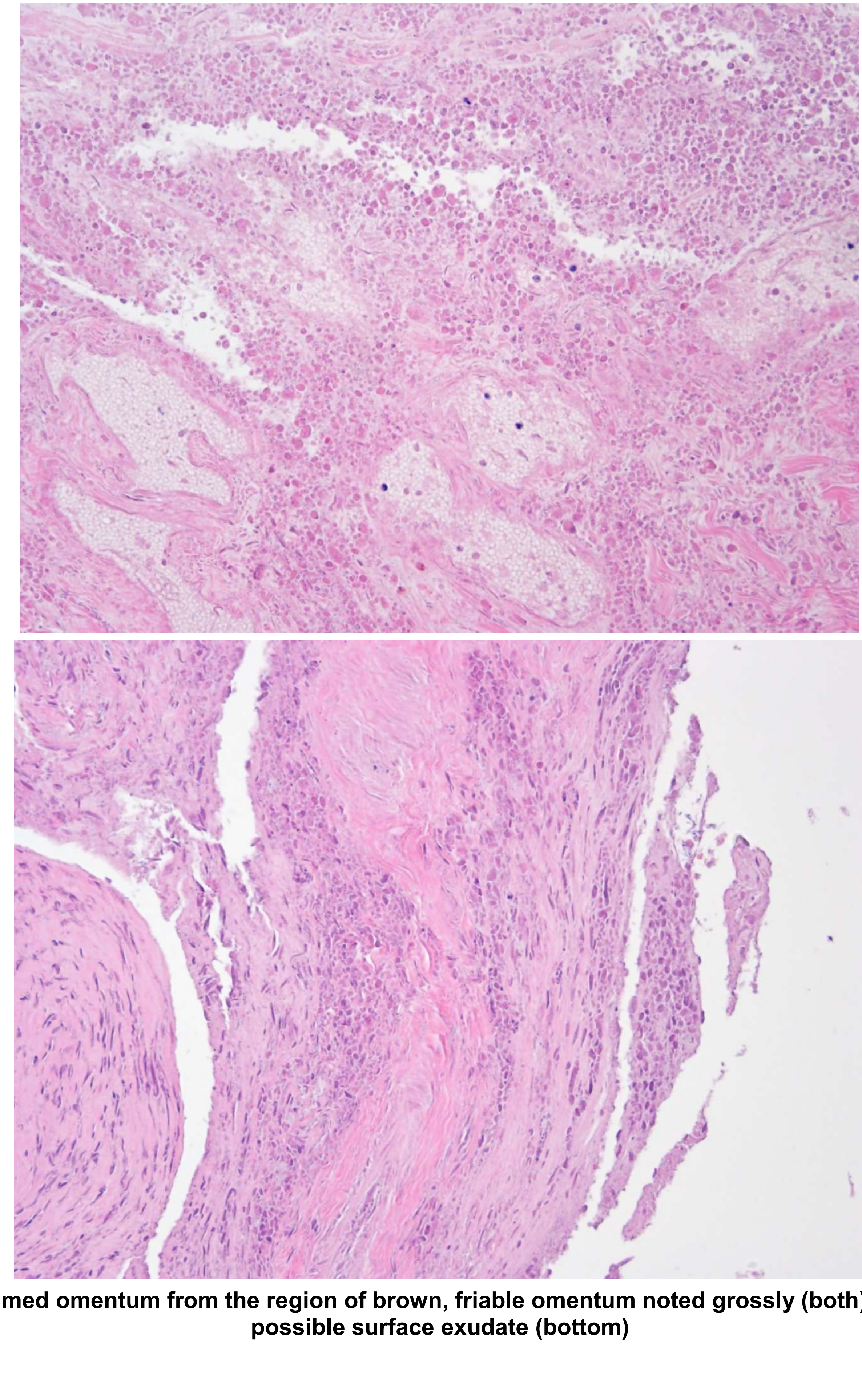


The heart was dilated with a prominent double apex, and the myocardium was diffusely pale. A region of reddish-black tissue discoloration was apparent along the junction between the left and right ventricles

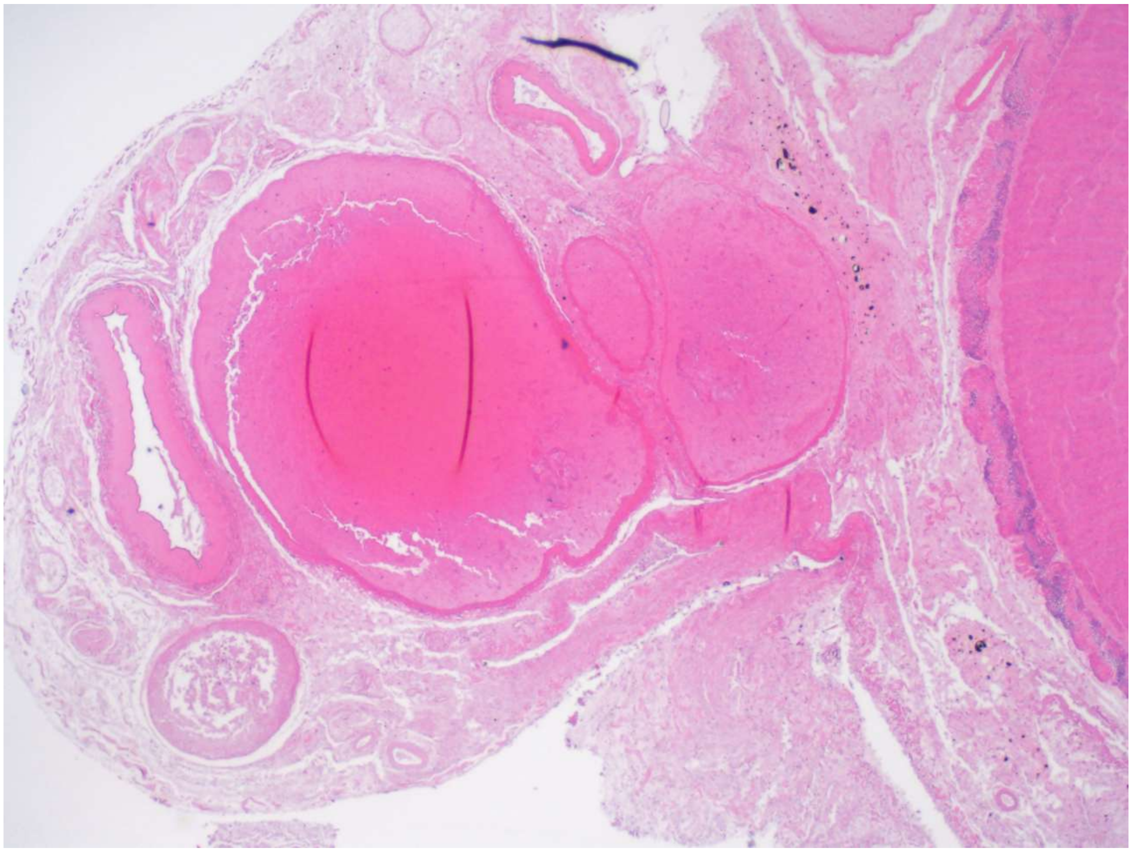


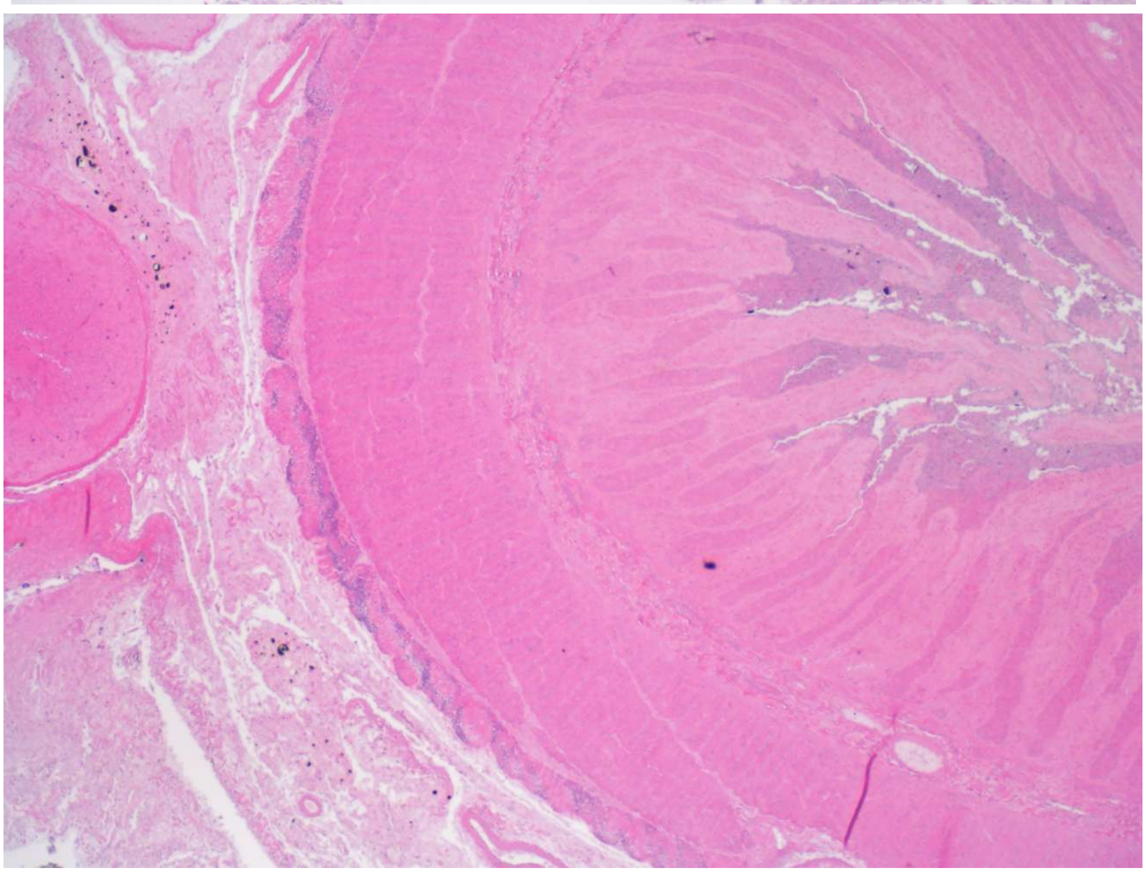


<u>Histology:</u> Inflamed omentum from the TDR (top) & VHF transmitter entrapment points (bottom)

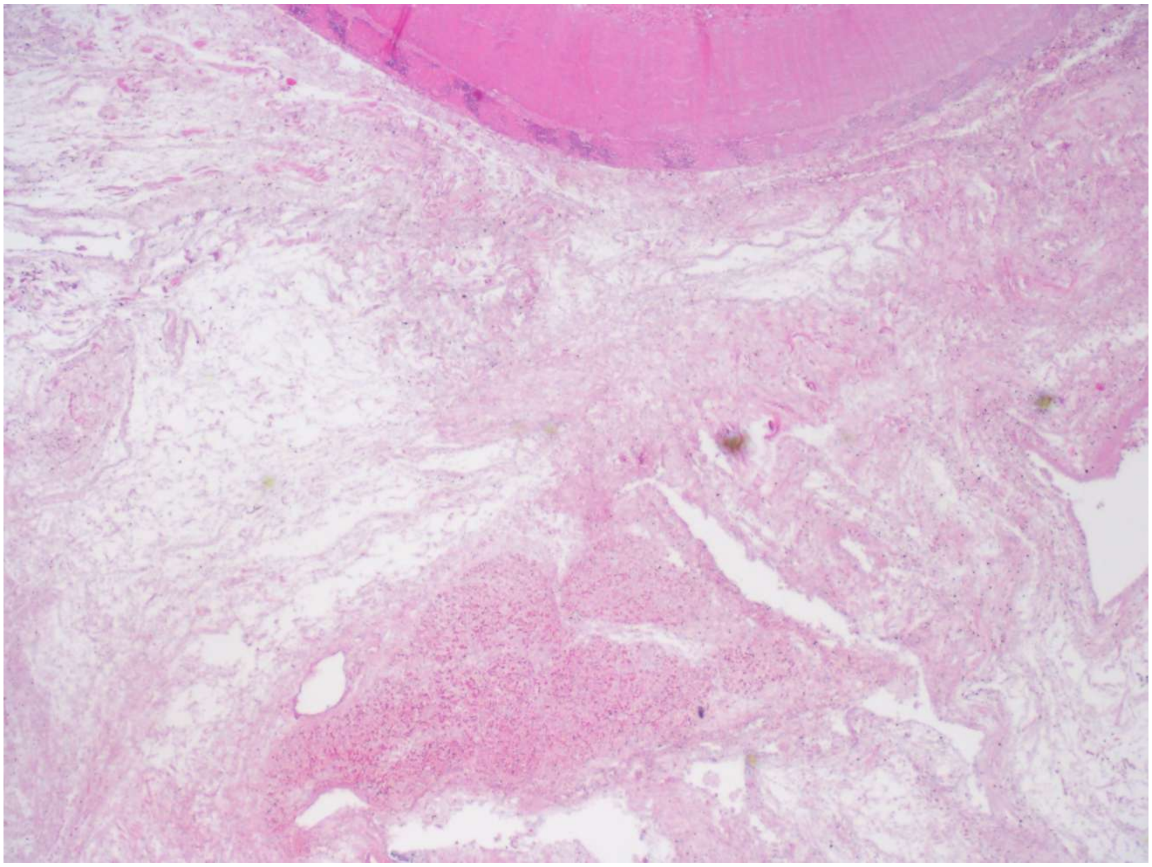


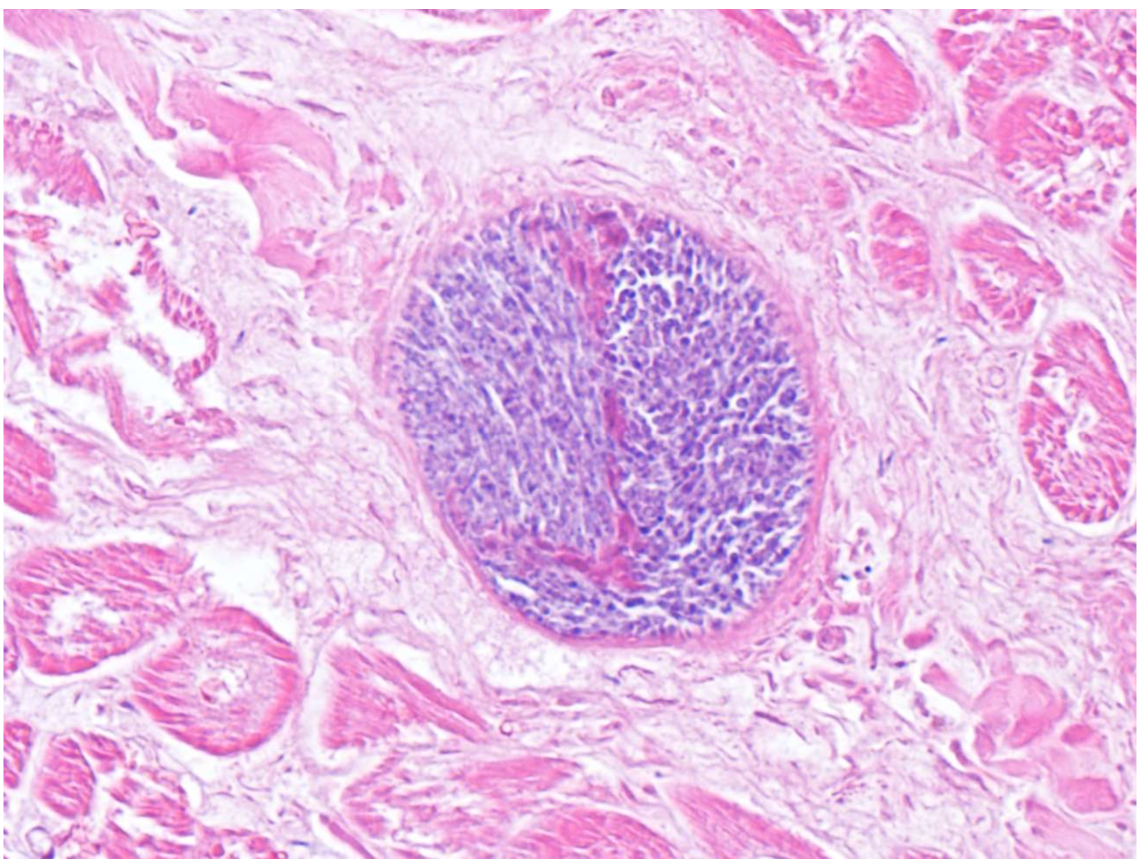
Inflamed omentum from the region of brown, friable omentum noted grossly (both), with possible surface exudate (bottom)





Marked mesenteric venous congestion (top) and possible severe mucosal congestion, small intestine (bottom)





Possible mesenteric hemorrhage & edema near intestine, same area as above photos (top)
Possible protozoal tissue cyst (sarcocyst), myocardium (bottom)

HISTOPATHOLOGY:

Letter	Tissue	Comment	PathologistComment
All tissues			Marked diffuse autolysis with PM bacterial proliferation
A	Cerebrum & cerebellum		WNL. Tissue is highly fragmented. Mild/mod congestion. Possible mild capillary neutrophilia.
B	Cerebellum & brainstem		WNL. Tissue is highly fragmented. Mild/mod congestion. Possible mild capillary neutrophilia. Large gas bubbles.
C	Lung		WNL. Severe autolysis with large gas bubbles.
C	Cerebellum		WNL. Tissue is highly fragmented. Mild/mod congestion. Possible mild capillary neutrophilia. Large gas bubbles.
D	Lung		WNL. Severe autolysis with large gas bubbles & bacterial proliferation. Possible antemortem septal edema.
E	Heart	Aorta	WNL
E	Heart	Right Ventricle Papillary Muscle	WNL. Possible mild patchy myofiber dropout with associated interstitial fibrosis? Marked postmortem mixed bacterial proliferation.
F	Heart	Right Ventricle Papillary Muscle	WNL. Possible mild/mod patchy myofiber dropout with associated interstitial fibrosis? Marked postmortem mixed bacterial proliferation.
F	Heart	Right A/V	WNL. Possible mild/mod patchy myofiber dropout with associated interstitial fibrosis? Marked postmortem mixed bacterial proliferation.
G	Heart	Left Ventricle Papillary Muscle	WNL. Mild patchy myofiber dropout with associated interstitial fibrosis. Marked postmortem mixed bacterial proliferation. Possible mild endocardial suppurative inflammation? Mild valvular endocardiosis. Large gas bubbles.
G	Heart	Septum	WNL. Mild patchy myofiber dropout with associated interstitial fibrosis. Marked postmortem mixed bacterial proliferation. Possible mild endocardial suppurative inflammation? Mild valvular endocardiosis. Large gas bubbles.

H	Heart	Left Ventricle Papillary Muscle	WNL. Possible mild patchy myofiber dropout with associated interstitial fibrosis. Marked postmortem mixed bacterial proliferation. Large gas bubbles.
H	Heart	Left A/V	WNL. Possible mild patchy myofiber dropout with associated interstitial fibrosis. Marked postmortem mixed bacterial proliferation. Large gas bubbles.
I	Heart	Left A/V	Focally extensive possible antemortem epicardial hemorrhage. Possible mild patchy myofiber dropout with associated interstitial fibrosis. Marked postmortem mixed bacterial proliferation. Large gas bubbles.
I	~~Mammary tissue~~	~~Pink in middle~~	Not present on slide
J	Heart	Left Ventricle Papillary Muscle	Moderate patchy myofiber dropout with associated interstitial fibrosis. Focal intracytoplasmic protozoal tissue cyst in adjacent LVFW (Likely sarcocyst-PHOTO). Marked postmortem mixed bacterial proliferation. Large gas bubbles.
J	Heart	Heart bruising	WNL. Moderate serous atrophy of adipose in poss. Area of "hemorrhage?". Possible mild patchy myofiber dropout with associated interstitial fibrosis. Marked postmortem mixed bacterial proliferation. Large gas bubbles.
K	Heart	Left Ventricle Papillary Muscle	Moderate patchy myofiber dropout with associated interstitial fibrosis. Marked postmortem mixed bacterial proliferation. Large gas bubbles.
K	Heart	Left A/V	Mild patchy myofiber dropout with associated interstitial fibrosis (incl. atrial wall). Marked postmortem mixed bacterial proliferation. Large gas bubbles.
L	Heart	Apex	Mild/mod patchy myofiber dropout with associated interstitial fibrosis (esp. septum & LVFW). Marked postmortem mixed bacterial proliferation. Large gas bubbles.
M	Heart	Heart bruising	"Bruising" corresponds with area of focally ext. proteinacious perivascular fluid leakage (Unk if antemortem or PM) and serous atrophy of coronary adipose. Mild patchy myofiber dropout with associated interstitial fibrosis.

N	Heart	Heart bruising	"Bruising" corresponds with area of focally ext. proteinacious perivascular fluid leakage (Unk if antemortem or PM) and serous atrophy of coronary adipose. Mild+ patchy myofiber dropout with associated interstitial fibrosis.
O	Adrenal Gland	Right, 2 sections	WNL. Gas bubbles.
O	Kidney	Right	WNL. Possible mild cortical thinning and minimal papillary tubular mineralization.
P	LN Axillary	Left	WNL? Severe autolysis.
P	Adrenal Gland	Left, 2 sections	WNL. Gas bubbles.
Q	Kidney	Left	WNL. Possible mild cortical thinning and minimal papillary tubular mineralization.
R	Omentum	Healthy omentum, 5 sections	Omentum is moderately to markedly thickened and hypercellular, with probable expansion by macrophages +/- other inflammatory cells (unable to determine cell types due to severe autolysis and bacterial proliferation) (PHOTO). Sparse areas of remaining mesothelium appear tall and hypertrophic (PHOTO). In some areas the omental structure is diffusely pale eosinophilic (due to severe autolysis, unable to confirm whether this associated with antemortem omental infarction or is all PM autolysis) (PHOTO).
S	Omentum	Unhealthy omentum, 6 sections	The tissue is highly fragmented and is moderately to markedly expanded by dense sheets of inflammatory cells (PHOTO). In some areas there is a surface coating of inflammatory cells, cell debris and proteinacious material (fibrin?) (PHOTO). Mixed bacteria are abundant. No residual fragments of acanthocephalans are apparent in any omental section.
T	Intestinal Contents	3 sections, 1 from each piece of intestine sampled	There is marked diffuse mesenteric (+/- mucosal?) venous congestion in two of the three sections (PHOTO). Areas of more severe mesenteric vascular congestion are associated with areas of possible mesenteric hemorrhage and edema (PHOTO).
U	LN Mesenteric		Severe autolysis & gas bubbles.
U	Spleen		Severe autolysis & gas bubbles.
V	Tongue	2 sections	Possible intranuclear viral inclusions associated with mild hyperkeratosis.

W	Liver	1 section each cassette, only one piece of liver sampled, not specified left or right	Marked diffuse autolysis with multiple large gas bubbles.
X	Liver	1 section each cassette, only one piece of liver sampled, not specified left or right	Marked diffuse autolysis with multiple large gas bubbles.
Y	Liver	1 section each cassette, only one piece of liver sampled, not specified left or right	Marked diffuse autolysis with multiple large gas bubbles.
Z	Stomach	2 sections each cassette, body sections to pyloric sections	Marked diffuse autolysis.
AA	Stomach	2 sections each cassette, body sections to pyloric sections	Marked diffuse autolysis.

BB	Stomach	2 sections each cassette, body sections to pyloric sections	Marked diffuse autolysis.
CC	Abdominal Wall	Surgical site, 3 sections	Mildly inflamed adhesion on peritoneal surface of 1/3 sections.
DD	Mesentery, omentum, intestine	~~Mesentery with acanths?, 2 - 3 sections~~	Several sections of variably inflamed and congested omentum (pres.), mesentery and severely autolyzed intestine. No sections of acanthocephalans are apparent.
EE	Intestine	Intestine with fibrin?, 3 sections	Several sections of severely autolyzed intestine with variable (mild-severe) mural congestion. No sections of acanthocephalans are apparent.
FF	Intestine	Intestine with fibrin?, 2 sections	Several sections of variably inflamed and congested omentum (pres.), mesentery and severely autolyzed intestine. No sections of acanthocephalans are apparent.
GG	Omentum	Omentum attached to abdominal wall, 4 sections	Several sections of variably inflamed and congested omentum (pres.). No sections of acanthocephalans are apparent.
HH	Omentum	TDR pocket, 7 sections	Several sections of variably fragmented and severely inflamed and congested omentum (pres.) with possible surface exudate (PHOTO). Possible patchy mural fibroplasia/granulation tissue. No sections of acanthocephalans are apparent.
II	Omentum	VHF pocket, 8 sections	Several sections of variably fragmented and severely inflamed and congested omentum (pres.) with possible surface exudate (PHOTO). Possible patchy mural fibroplasia/granulation tissue (PHOTO). No sections of acanthocephalans are apparent.

JJ	Abdominal Wall	Adhesion site on abdominal wall	Section of mild/moderately inflamed omentum (pres.) with possible surface exudate attached to ventral body wall (minus integument). Patchy mild fibroplasia/granulation tissue. No sections of acanthocephalans are apparent. Inflammation appears to be concentrated on the surface of the omental remnant and ventral abdominal peritoneum
KK	Abdominal Wall	Adhesion site on abdominal wall	Section of mild/moderately inflamed omentum (pres.) with possible surface exudate attached to ventral body wall (minus integument). Patchy mild fibroplasia/granulation tissue. No sections of acanthocephalans are apparent. Inflammation appears to be concentrated on the surface of the omental remnant and ventral abdominal peritoneum
LL	Abdominal Wall	Adhesion site on abdominal wall	Section of mild/moderately inflamed omentum (pres.) with possible surface exudate attached to ventral body wall (minus integument). Patchy mild fibroplasia/granulation tissue. No sections of acanthocephalans are apparent. Inflammation appears to be concentrated on the surface of the omental remnant and ventral abdominal peritoneum
MM	Abdominal Wall	Adhesion site on abdominal wall	Section of mild/moderately inflamed omentum (pres.) with possible surface exudate attached to ventral body wall (minus integument). Patchy mild fibroplasia/granulation tissue. No sections of acanthocephalans are apparent. Inflammation appears to be concentrated on the surface of the omental remnant and ventral abdominal peritoneum
NN	Abdominal Wall	Adhesion site on abdominal wall	Section of mild/moderately inflamed omentum (pres.) with possible surface exudate attached to ventral body wall (minus integument). Patchy mild fibroplasia/granulation tissue. No sections of acanthocephalans are apparent. Inflammation appears to be concentrated on the surface of the omental remnant and ventral abdominal peritoneum
OO	Skin	Unspecified piece	WNL. Twisted. No visible mites.

CDFW SEA OTTER NECROPSY REPORT

California Department of Fish and Wildlife
Office of Spill Prevention and Response
Marine Wildlife Veterinary Care and Research Center
151 McAllister Way
Santa Cruz, CA 95060
(831) 469-1719

Sea Otter:	9103-18
UCD PATH:	18S0926
MWVCRC Necropsy	18-0504
Report Date:	11/19/2018
Report Status:	Gross

CASE PROFILE

DFG/BRD#:	1380	**Report By:**	Melissa Miller
UON#:	N-1656-18-S	**Necropsy By:**	Miller, Young, Batac, Dodd, Greenwald
MBA#:		**Necropsy Date:**	11/16/2018
Date Found:	11/15/2018	**Condition:**	Fresh
Condition Found:	Fresh	**Sex:**	Female
Live Strand:	No	**Age Class:**	Adult
Euthanized:	No	**Estimated Age:**	4-6 yrs by M. Miller
Date Died:		**Location:**	Monterey Harbor below Heritage Harbor
Total Length (cm):	121	**County:**	Monterey
Weight (kg):	22.5	**ATOS:**	377
Nutritional State:	Excellent	**DSOFS COD:**	11p
SQ Fat:	Abundant	**Histopathology:**	Full
Food in Gut:	None		

MORTALITY DATABASE CODING

Primary COD:
Possible A/SA DA
intox.
Sequela 1
Abortion
Sequela 2 Aspiration
pneumonia
Secondary COD:
Lymphadenopathy,
Unk cause
Tertiary COD: None
Quaternary COD: None

CASE BACKGROUND

Captured in March 2018 and only tagged because she was pregnant: 3/19/2018, at Monterey Bay Inn, 20.3 kg, 117.5 cm, no VHF/TDR.

She was last seen with 1 tag on 29 Aug 2018 and was regularly resighted between Monterey Bay Inn and the harbor before that. No forage data was recorded for her.

GROSS DIAGNOSES

1.) Possible acute/subacute domoic acid intoxication char. by:

-Marked diffuse vascular congestion and multi-organ congestion (PHOTO)
-Blood-tinged fluid around nose & mouth (PHOTO)
-Hyphema OD>OS
-Brownish, “coffee colored” myocardium and moderately distended, blood-filled atria (PHOTO)
-Pericardial, pleural and mild peritoneal effusion, mild pulmonary edema (PHOTO)
-Possible mild/mod. caudal cerebellar herniation? (PHOTO)

1a.) Abortion/pre-term birth, pres. (Please see below for details) (PHOTO)

1b.) Aspiration pneumonia, left caudal lung lobe, focally extensive, severe, acute/subacute (PHOTO)

1c.) Mild fibrinous pleuritis, left hemithorax (PHOTO)

2.) Mild-marked patchy lymphadenopathy (esp. left retropharyngeal, left axillary, hilar LNs)

FETUS:

1.) Same as #1 above, char. by:
-Pre-term female fetus, head-up position (40.5 cm TL, 1115 gm) (PHOTO)
-Marked pericardial effusion, mild pleural and peritoneal serous effusion (PHOTO)
-Moderate patchy multi-organ congestion (PHOTO)
-Possible epicardial hemorrhage, moderate atrial distension (PHOTO)
-Severe meconium smearing
-Eyes closed, no teeth erupted, moderate to excellent adipose SQ, IP, coronary
-Placental ellipses fused, largest 10.5 x 4 cm
-Fetal membranes intact but partially extruded (~5 cm) into vaginal tract (abortion/parturition) (PHOTO)

INCIDENTAL FINDINGS:

1.) Nasal acariasis, mild

2.) Stage 2 female
-Exc. nutritional condition, abundant SQ, coronary IP adipose (PHOTO)
-Medium white nose wound
-Marked mammary development with scant lactation (PHOTO)
-Mild vulvar swelling (PHOTO)
-Right horn pregnancy, pre-term female fetus, head-up position (40.5 cm TL, 1115 gm) (PHOTO)
-Right ovary: ~1.5 cm CL, no visible CAs, follicles, PO cysts (PHOTO
-Left ovary: Single CA, no CL, follicles, PO cysts (PHOTO)
-Both ovaries ~50% of normal size for adult female (PHOTO)
-Cervix flaccid and fully open
-Uterine cytology (Diffquick): Unremarkable-Mostly sloughed cells and debris (No inflammatory cells, bacteria or other pathogens observed)

-No apparent dystocia, uterine torsion, etc.
-Fetal membranes intact but partially extruded into vaginal tract (abortion/parturition) (PHOTO)

3.) Mild melena

4.) Mild intestinal Corynosoma

GROSS SUMMARY

Pending biochemical testing and microscopic examination of all tissues, acute to subacute domoic acid intoxication is suspected as the cause of death.

Related findings include gross lesions consistent with abortion/premature birth of a female fetus, and aspiration pneumonia.

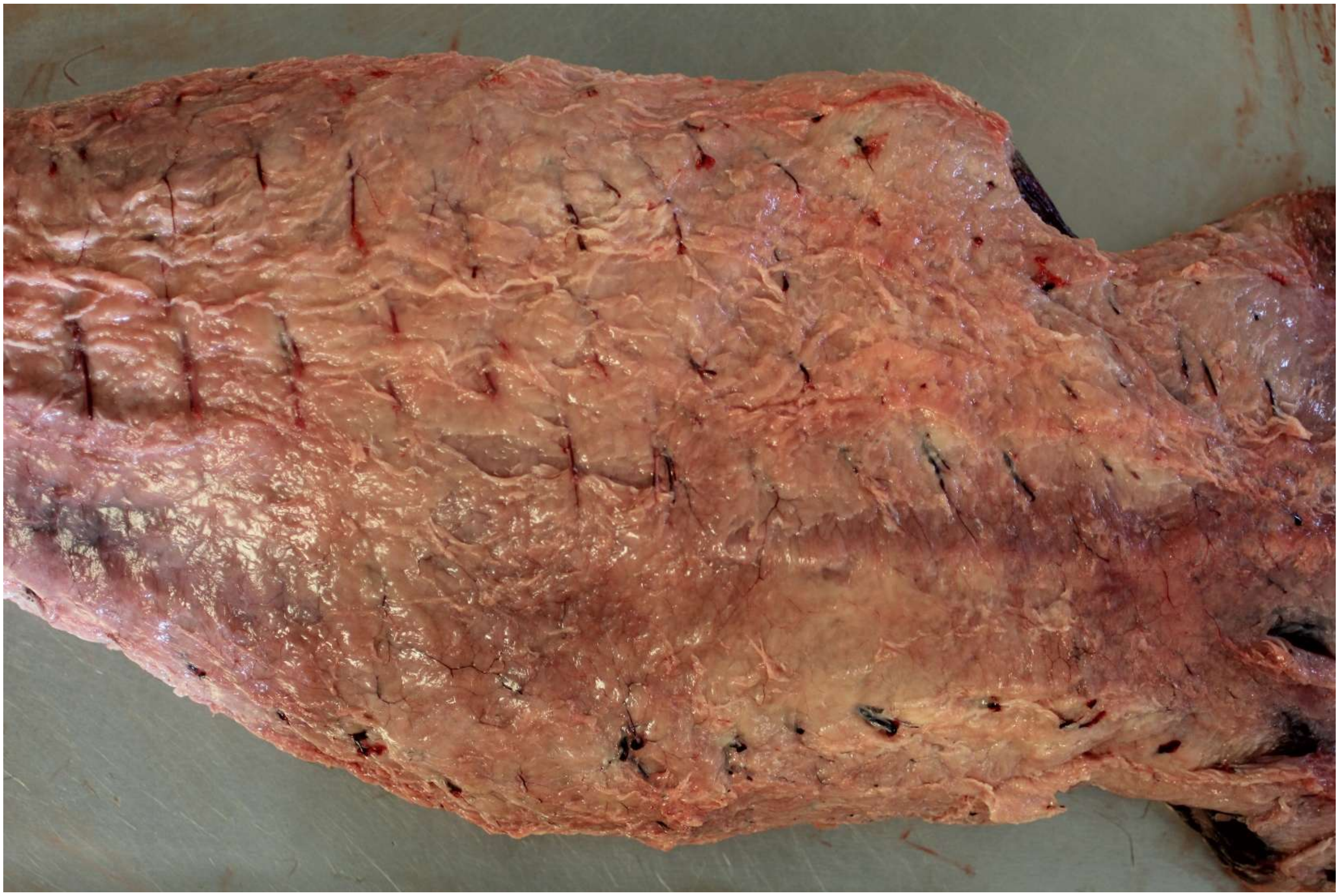
Observed lymphadenopathy may be indicative of concurrent disease-this COD will be updated as part of case completion.

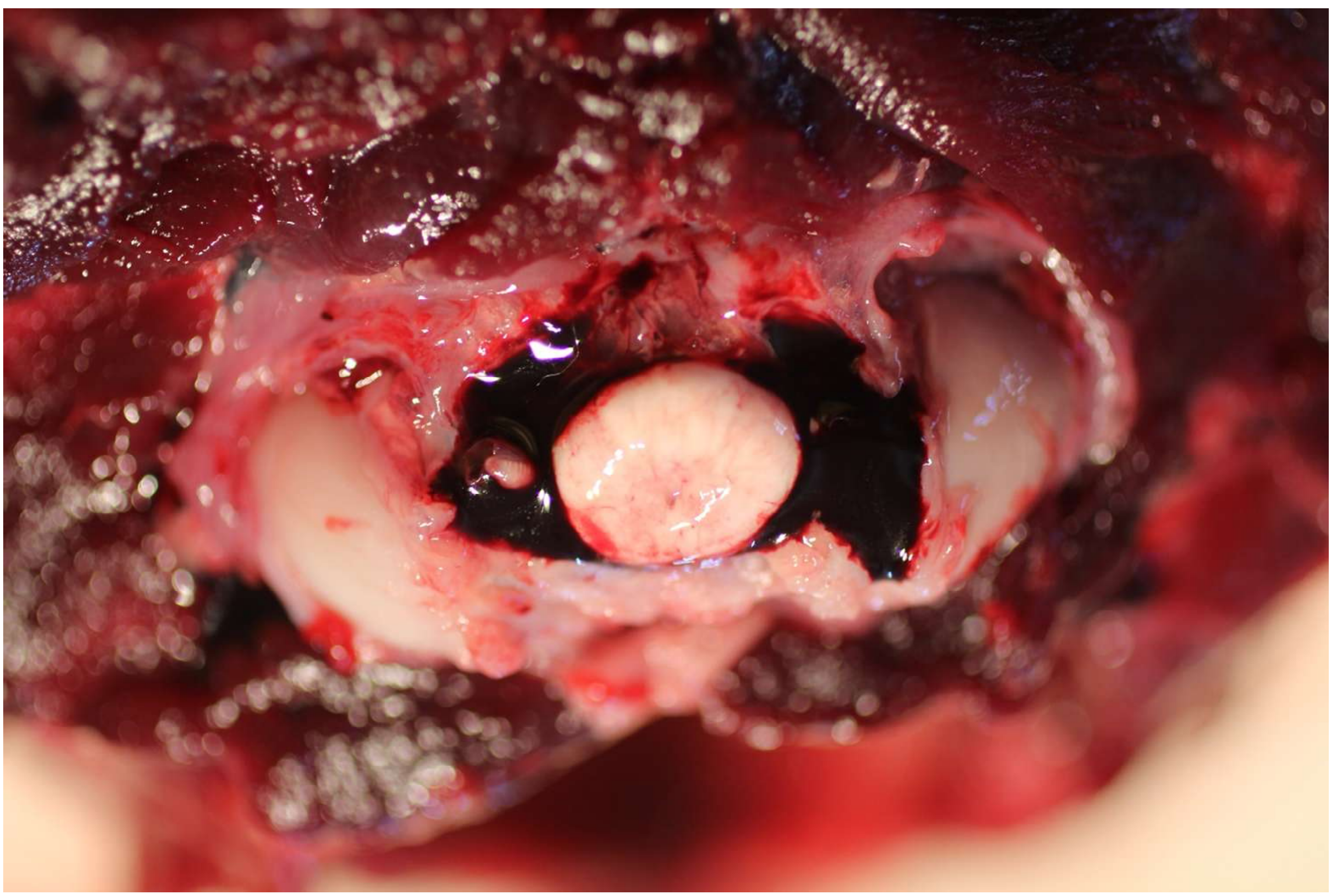
Pending:

- Full HP
- DA testing, maternal & fetal
- Bacterial culture of lung/hilar LN if needed following HP (samples cryoarchived-UCD closed due to Camp Fire)

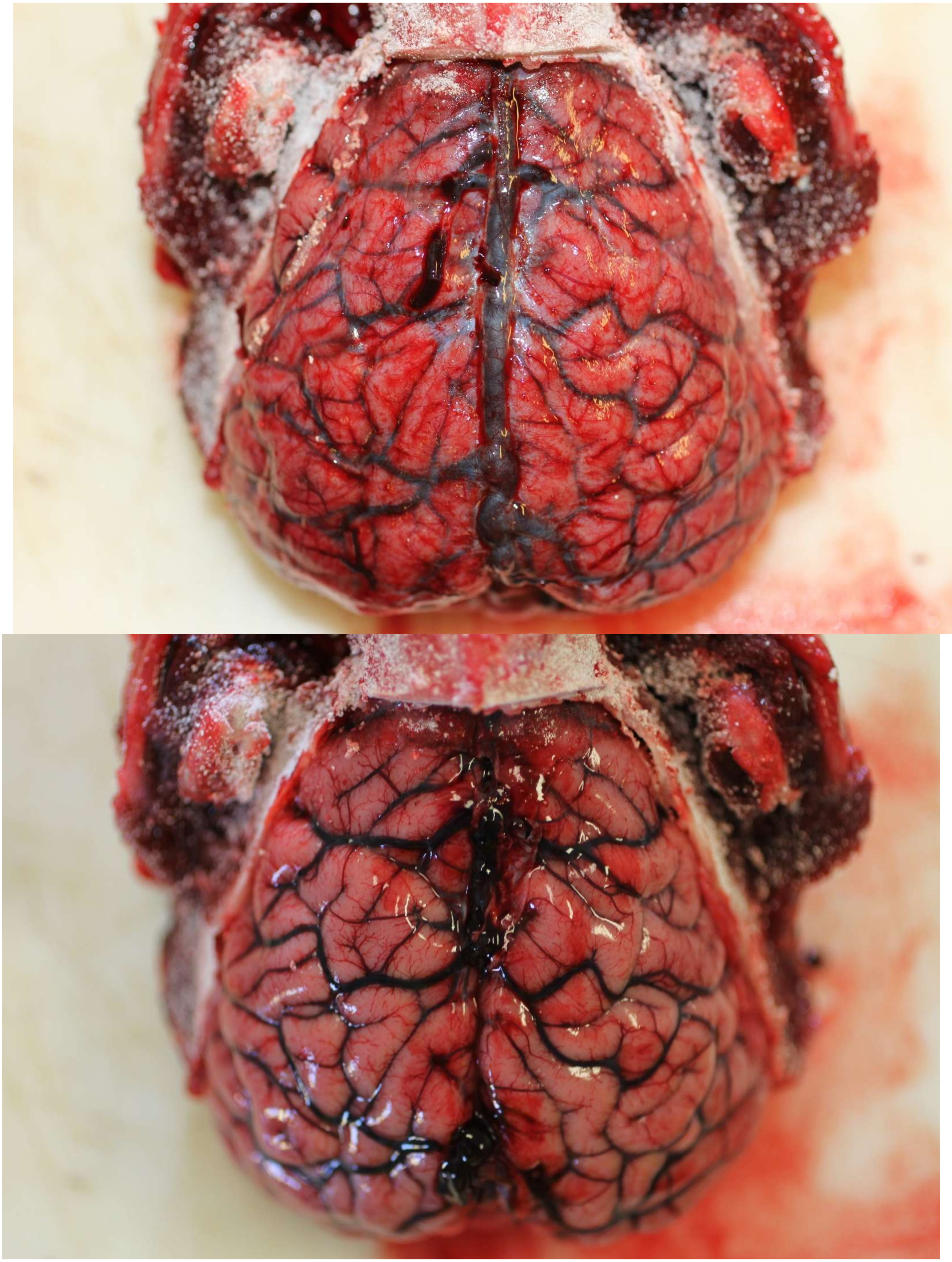
Saved/completed:

- All standard samples (mother and fetus) for cryo-archiving and histopathology
- Numerous gross photos
- Fetal amniotic and allantoic fluid, maternal & fetal upper and lower intestinal content
- Uterine cytology (Diffquick): Unremarkable-Mostly sloughed cells and debris (No inflammatory cells)
- Samples for pelt study (Tometz)

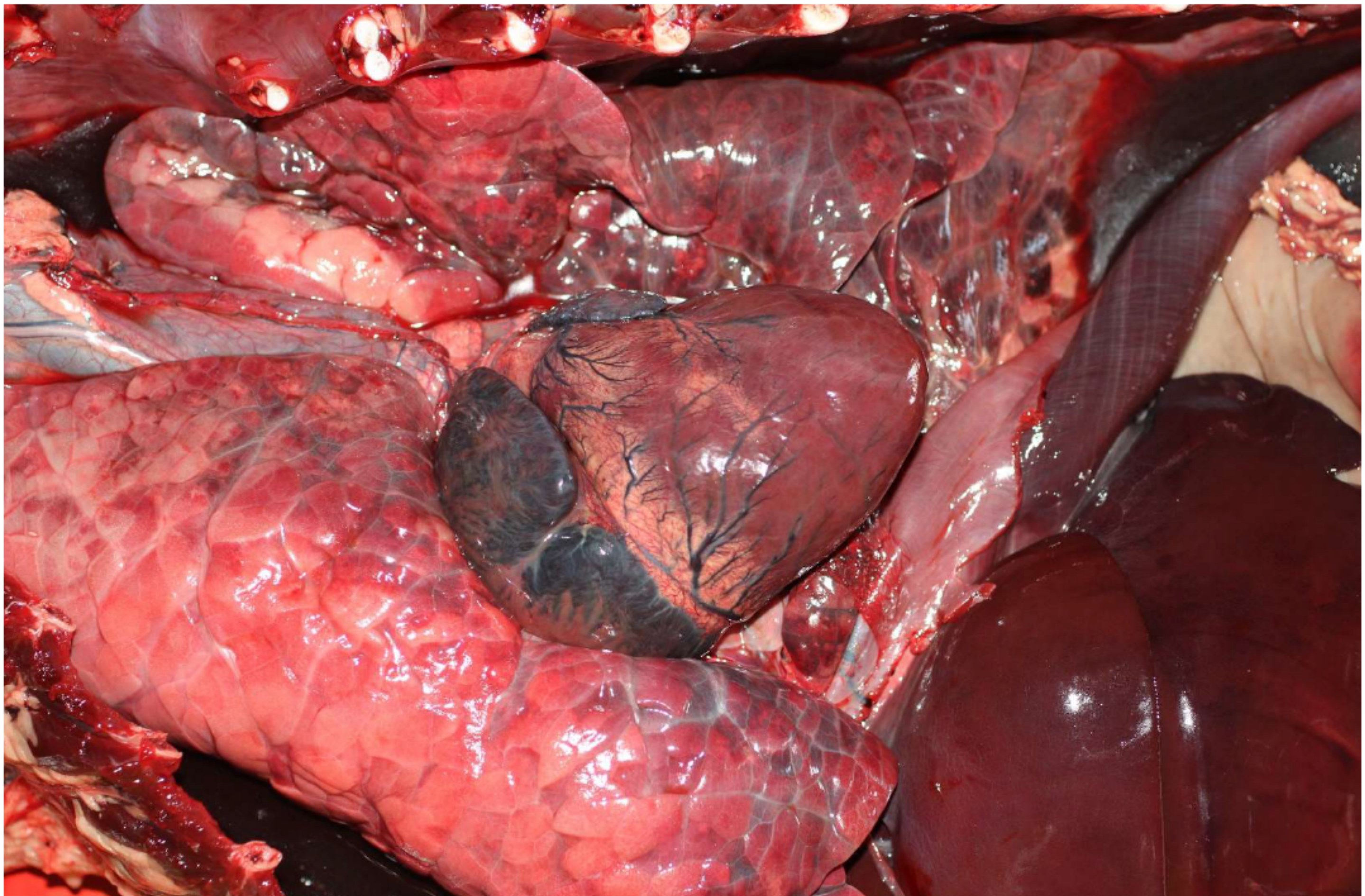


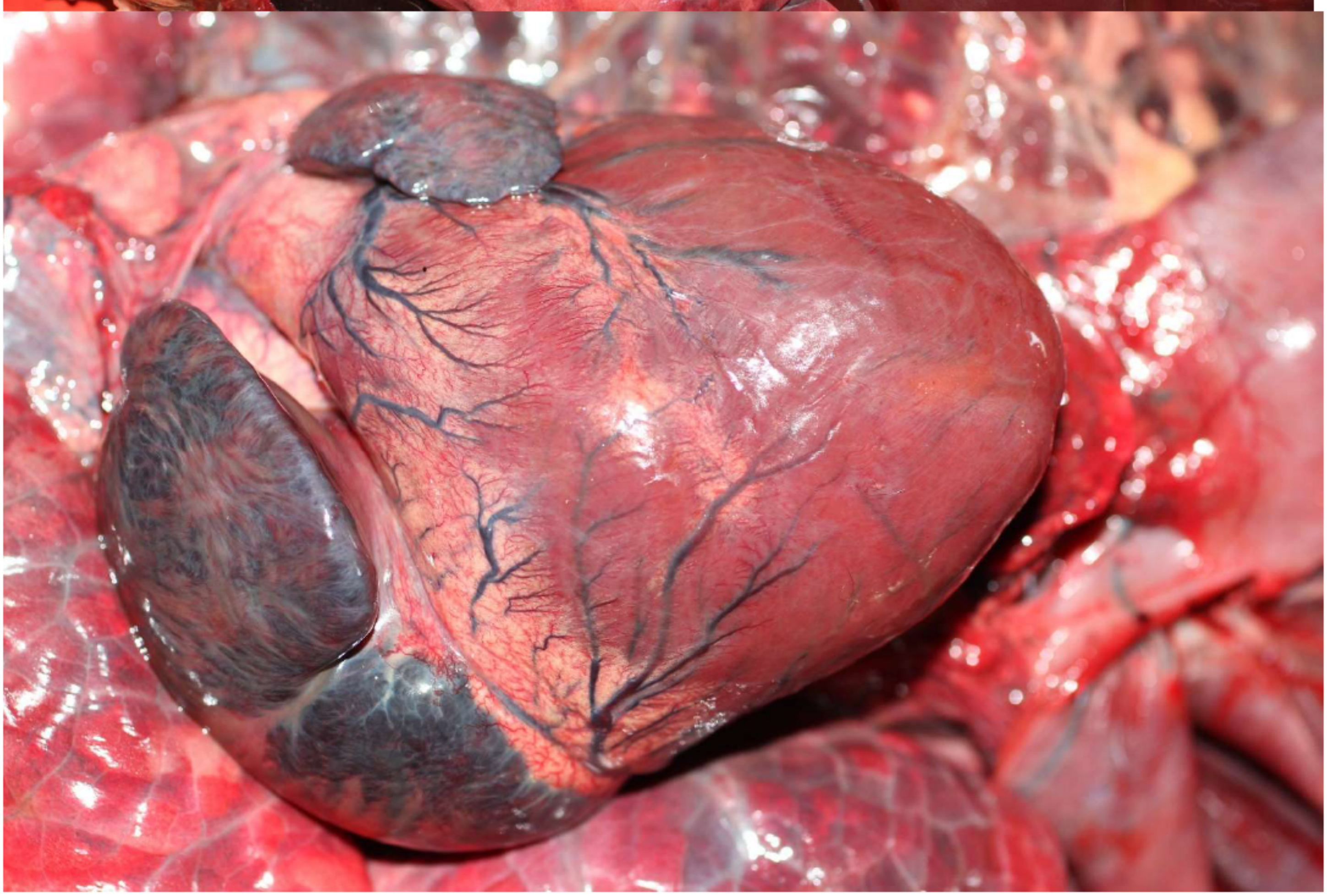


Top: Abundant SQ adipose Bottom: Marked vascular congestion around cervical spinal cord

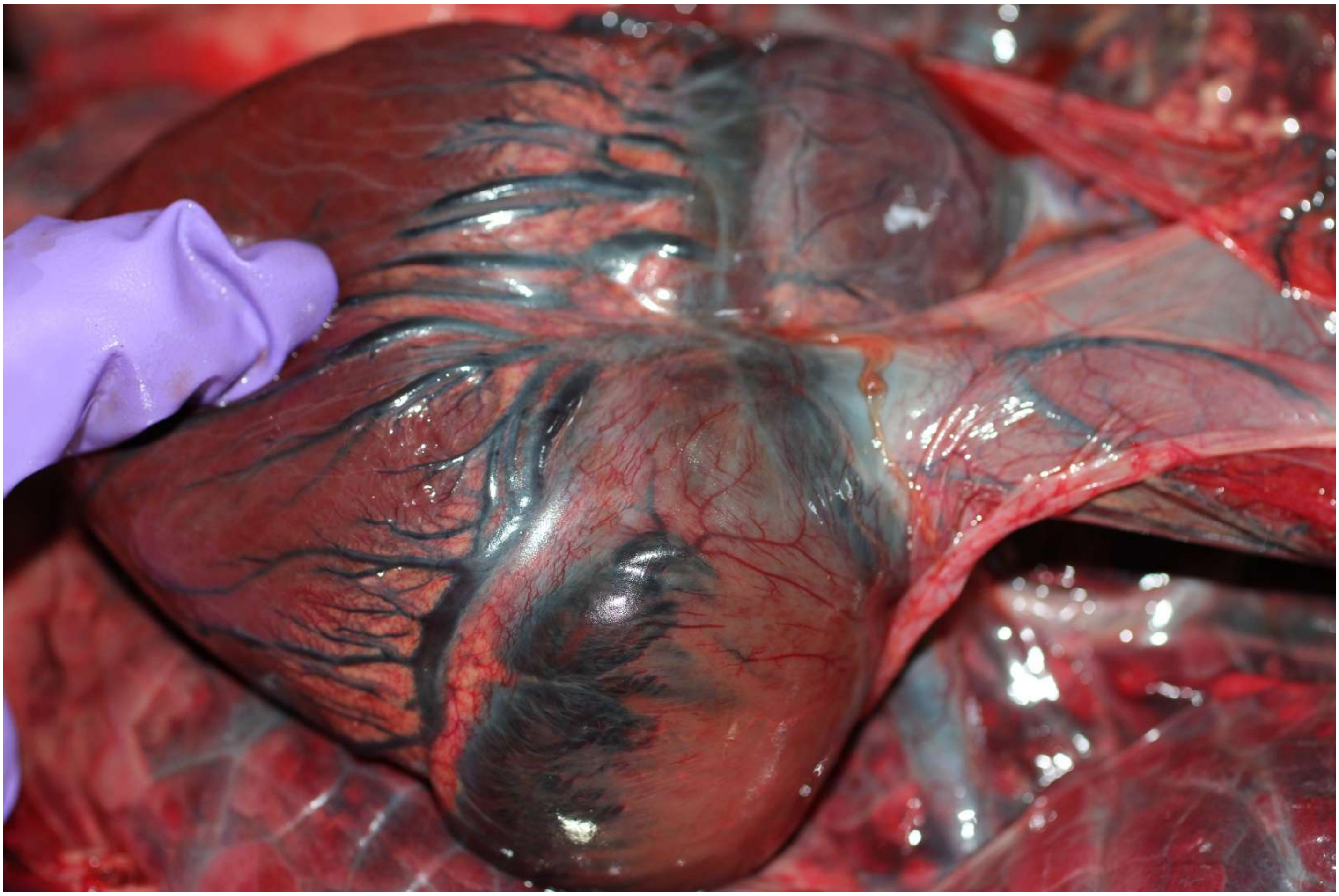


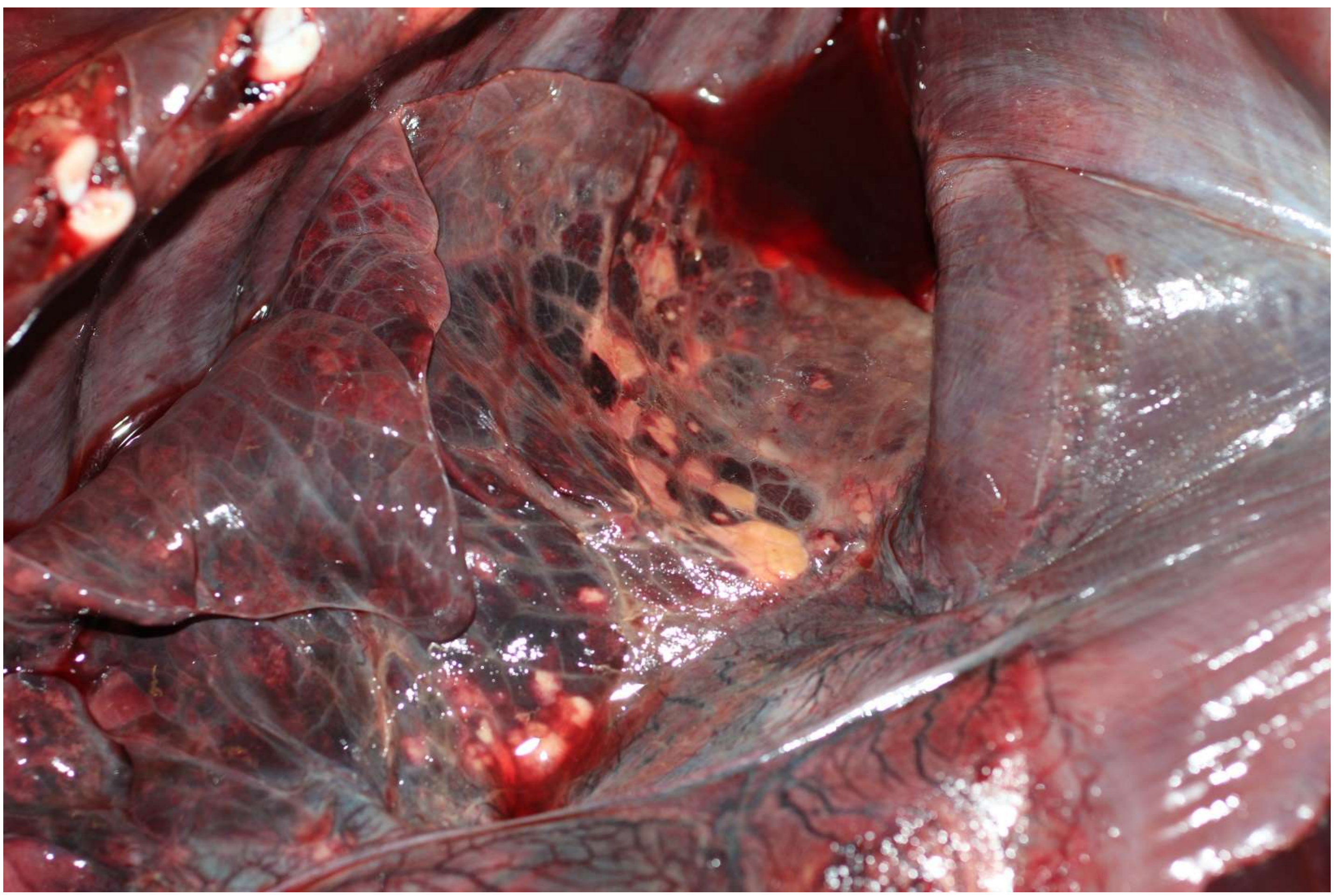
Marked diffuse vascular congestion, meninges (top) and brain (bottom)



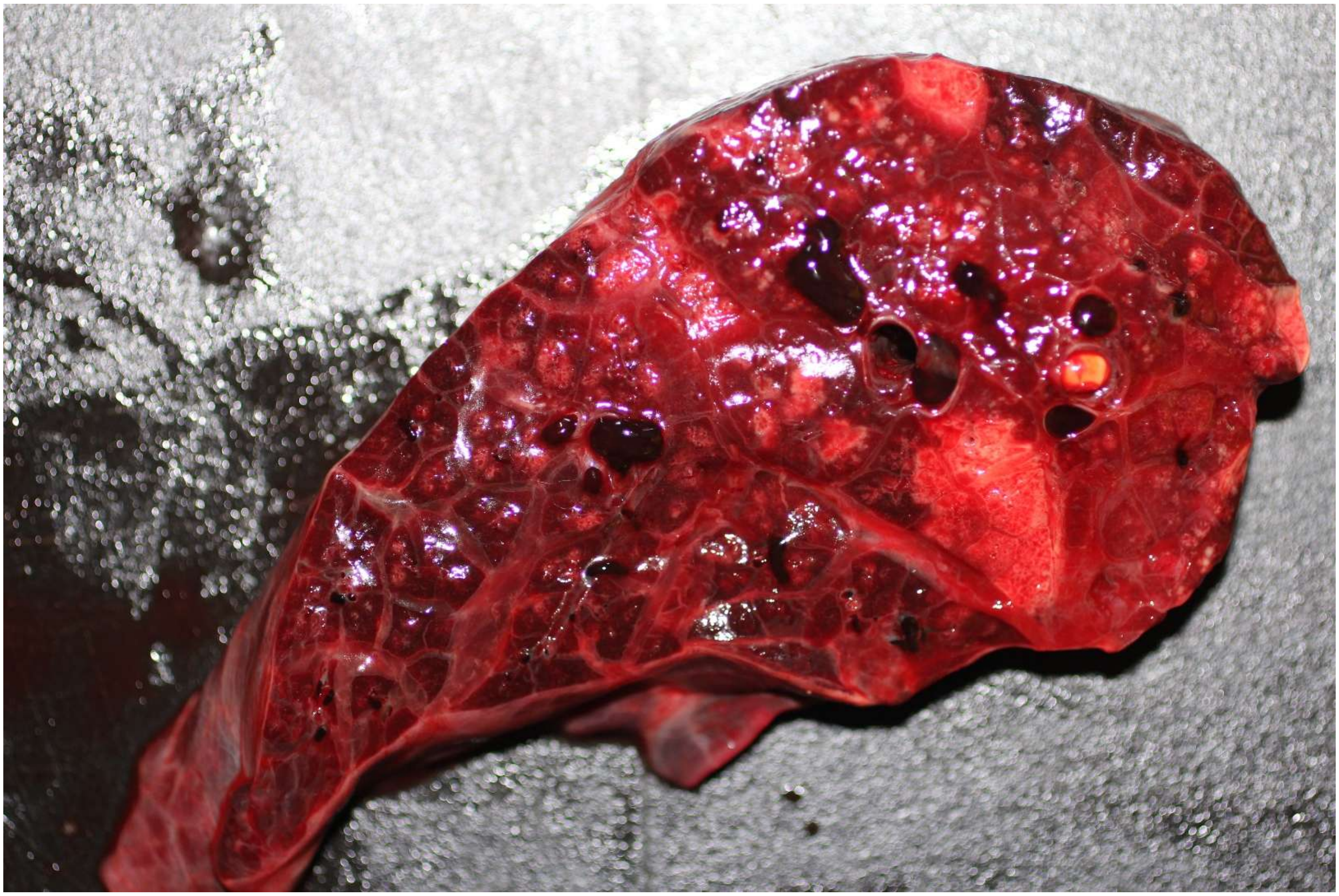


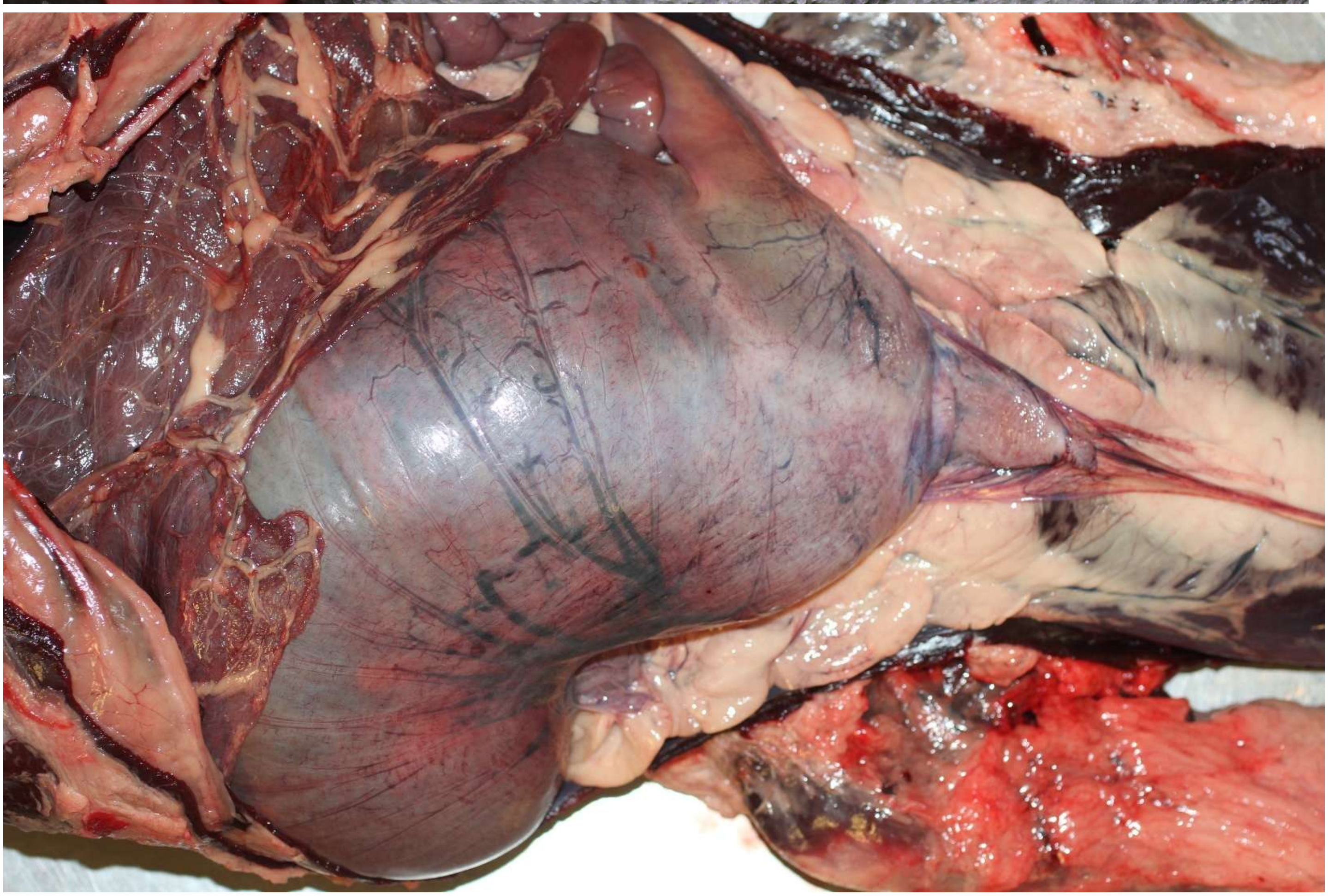
Pleural effusion (top) Brownish myocardium, prominent epicardial vessels & atrial dilation (bottom)



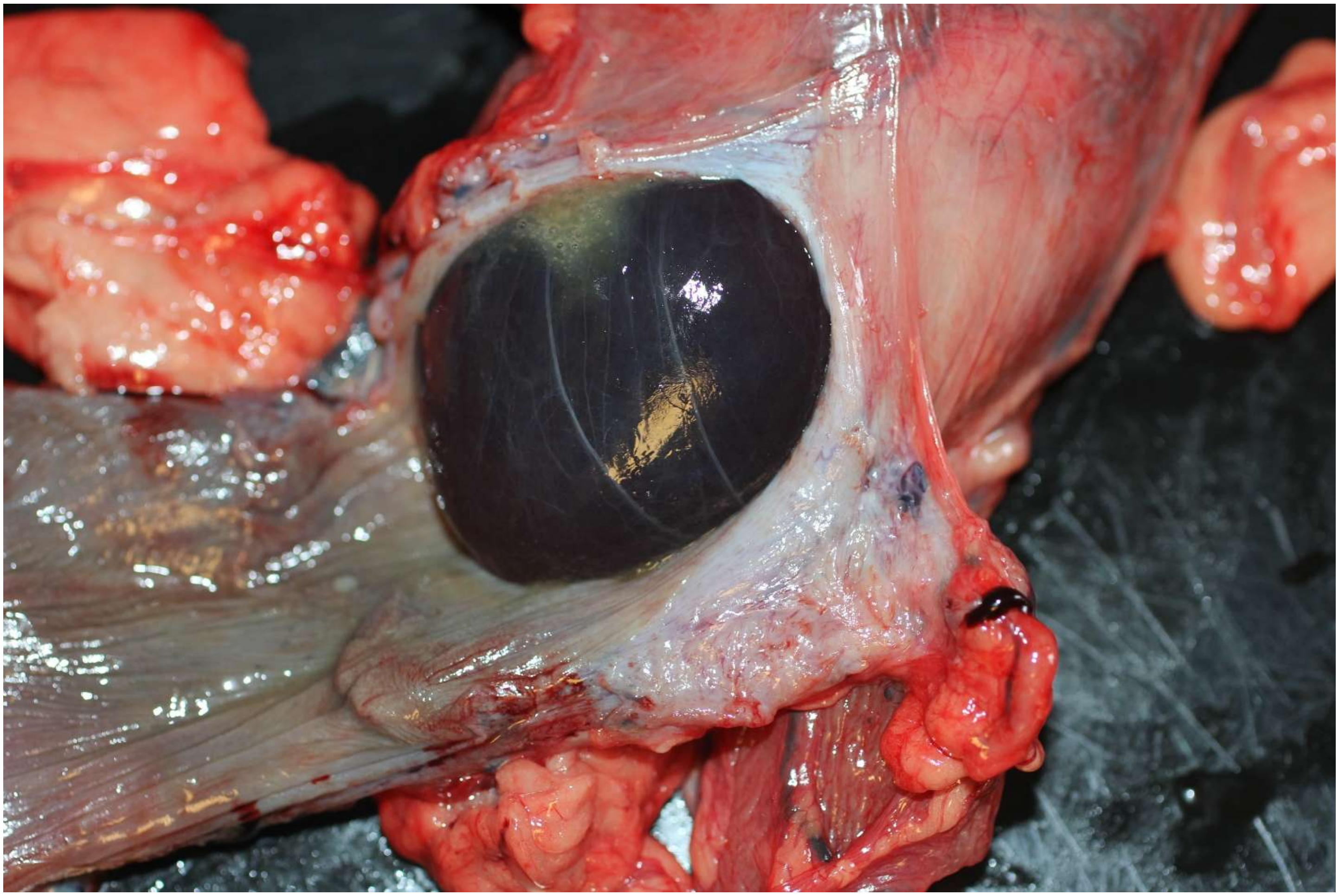


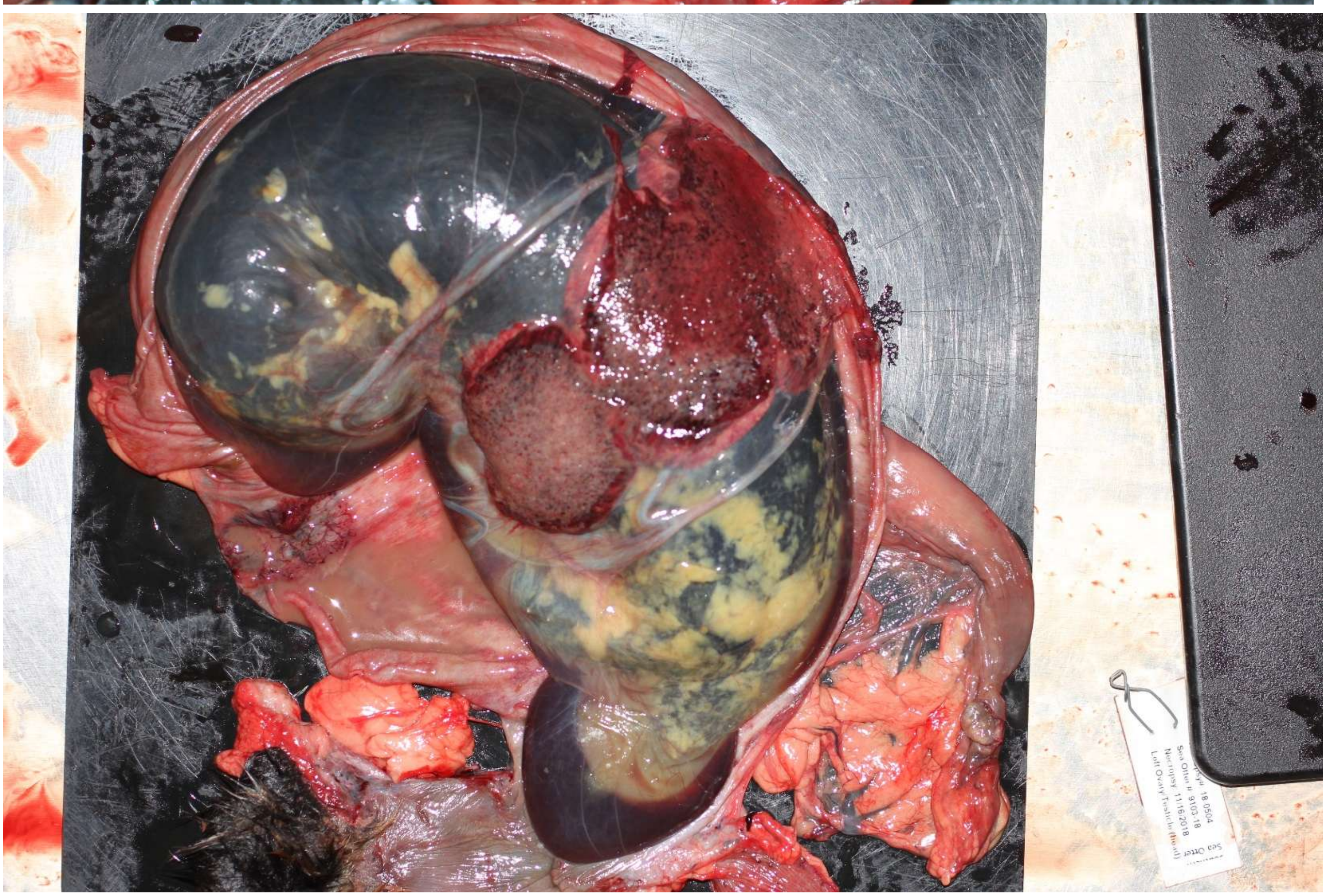
Brownish myocardium, atrial dilation (top)   Aspiration pneumonia, left caudal lung (bottom)



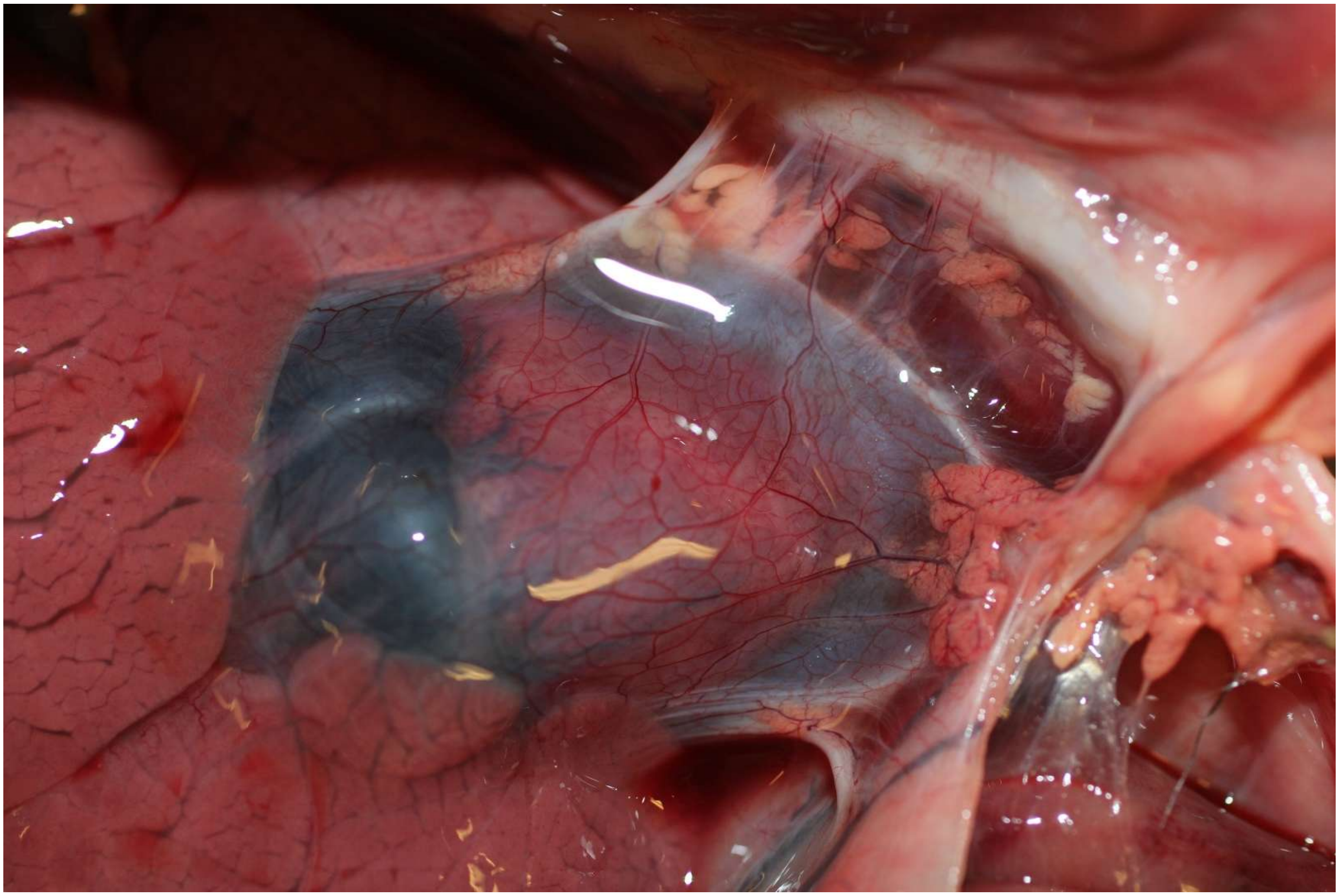


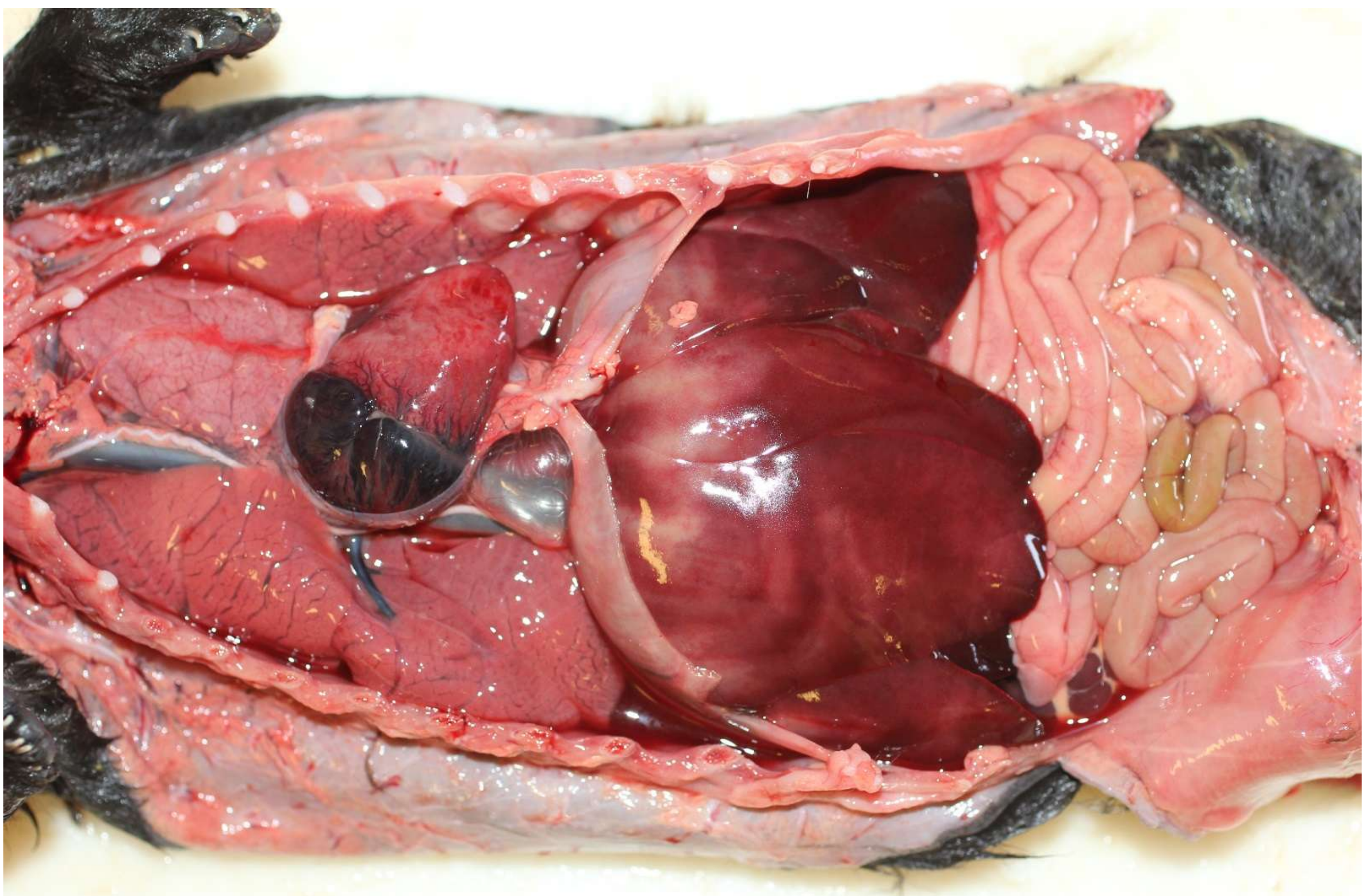
Aspiration pneumonia, left caudal lung (top) Right horn pregnancy (bottom)



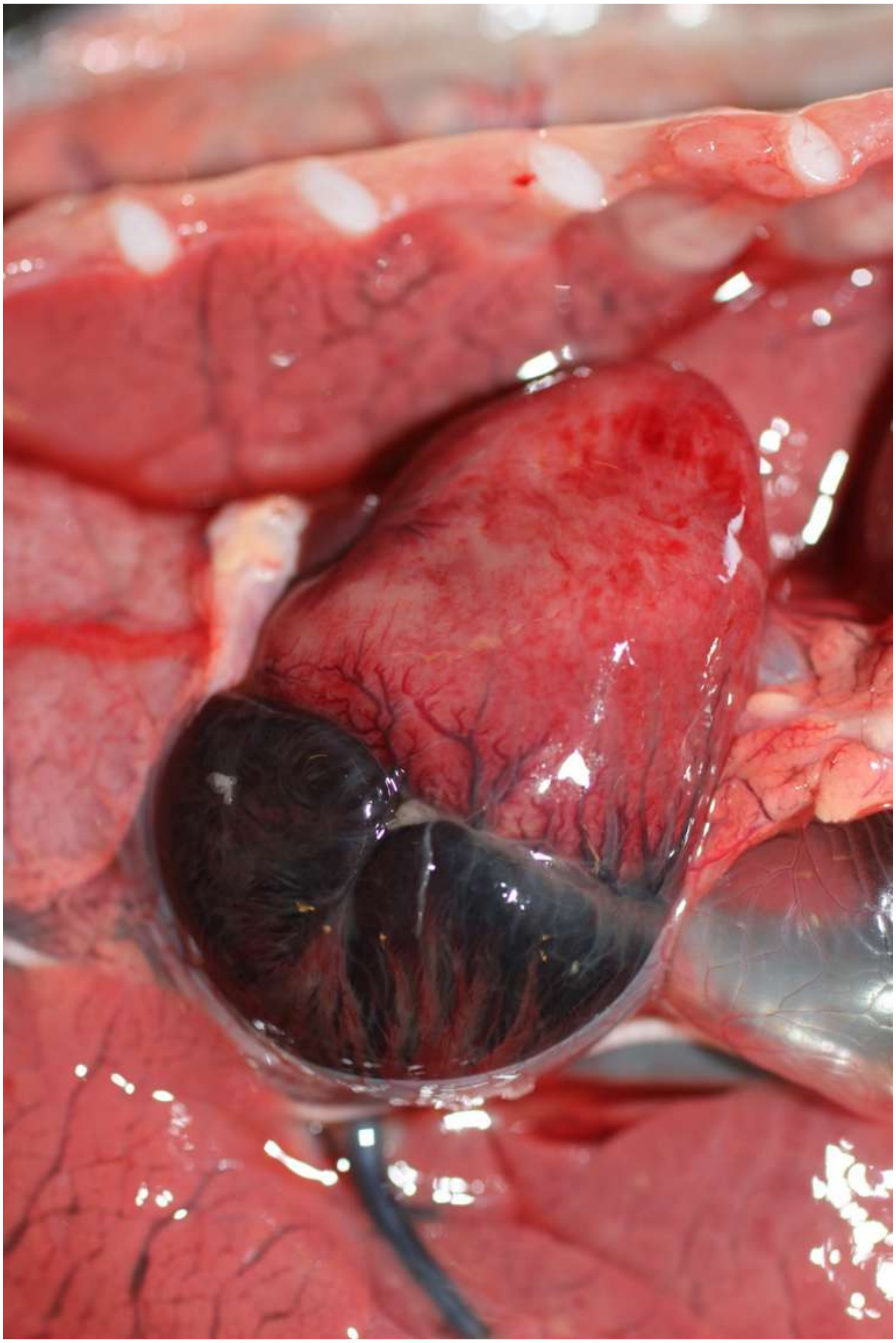


Fetal membranes in vaginal canal (abortion or pre-term birth) (top)
Severe fetal meconium smearing (fetal distress) (bottom)

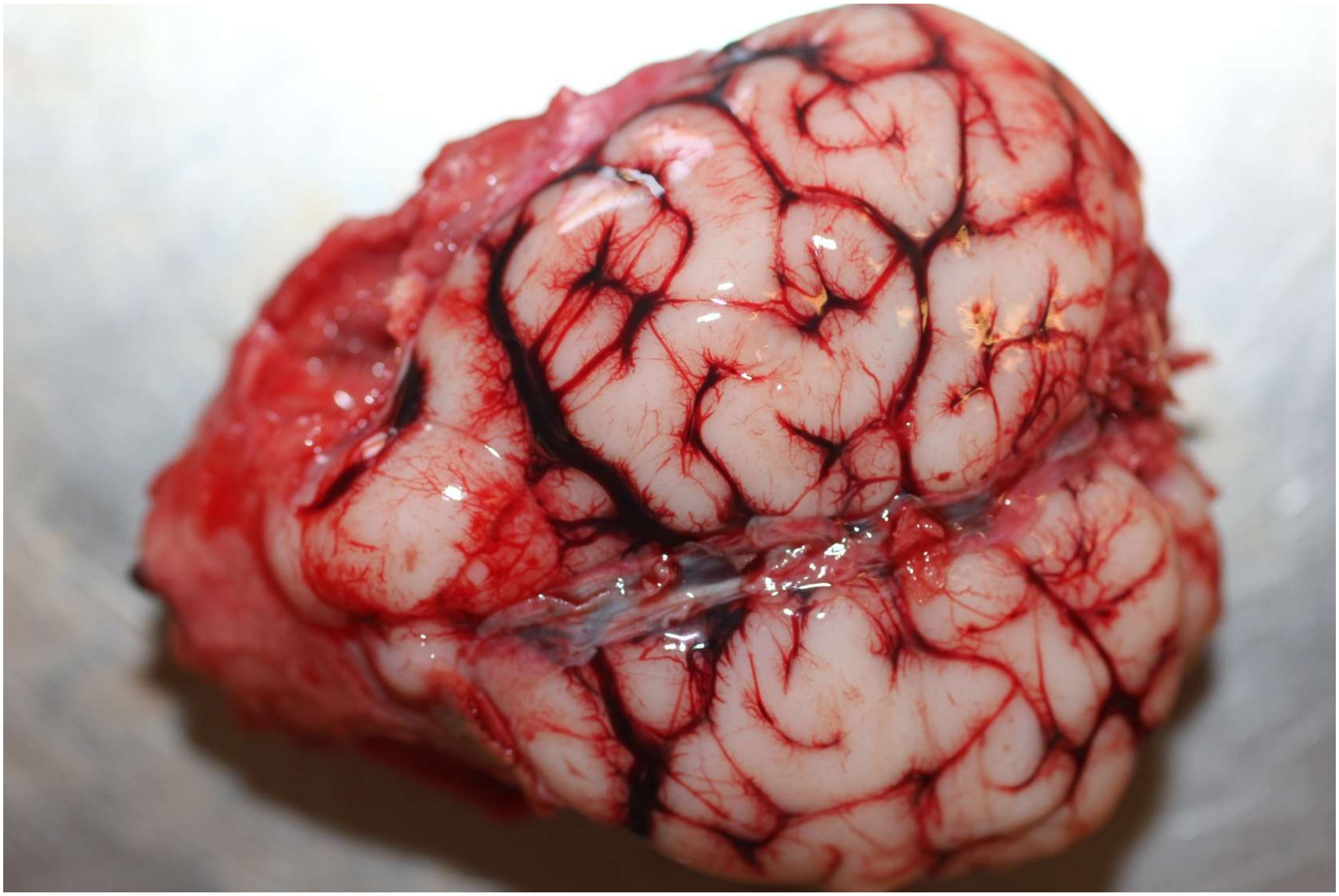




Fetus: Marked serous pericardial effusion (top)
Fetus: Myocardial congestion & possible epicardial hemorrhage (bottom)



Fetus: Myocardial congestion, atrial dilation & possible epicardial hemorrhage



Fetus: Marked vascular congestion, meninges

CDFW SEA OTTER NECROPSY REPORT

California Department of Fish and Wildlife
Office of Spill Prevention and Response
Marine Wildlife Veterinary Care and Research Center
151 McAllister Way
Santa Cruz, CA 95060
(831) 469-1719

Sea Otter:	9140-19
UCD PATH:	19S0010
MWVCRC Necropsy #	19-0006
Report Date:	1/18/2019
Report Status:	Gross

CASE PROFILE

DFG/BRD#:	1351	**Report By:**	Dr. Melissa Miller
UON#:	N-1627-16-S	**Necropsy By:**	Miller, Dodd, Batac, Young
MBA#:		**Necropsy Date**	1/7/2019
Date Found:	1/5/2019	**Condition:**	Fresh
Condition Found:	Fresh	**Sex:**	Female
Live Strand:	No	**Age Class:**	Adult
Euthanized:	No	**Estimated Age:**	9-10 yrs by M Miller
Date Died:		**Location:**	Monterey Harbor
Total Length (cm)	120.5	**County:**	Monterey
Weight (kg):	17.6	**ATOS:**	377B
Nutritional State:	Emaciated	**DSOFS COD:**	11
SQ Fat:	None	**Histopathology**	Full
Food in Gut:	Little		

MORTALITY DATABASE CODING

Primary COD : Cardiomyopathy

Sequela 1: L & R heart failure

Secondary COD: Poss ELS

Tertiary COD: Gastric erosions/melena

Quaternary COD: Poss SA/chronic DA intoxication.

CASE BACKGROUND

Teri Nicholson 05Jan2019:
Here is a fact sheet for the NSF study female I picked up today (05Jan2019). Her first capture was at Monterey Bay Inn on 6/2/2016 (tagged, radio transmitter freq. 166.380 and TDR implant), and her second was in Monterey harbor on 10/18/2018 (retag and TDR removal). During this time she has successfully reared 3 pups. She weaned her last pup (1390-18) in early November 2018. The pup was approximately 22 weeks old.

Her primary range was from Monterey Bay Inn to Wharf 2, but trackers have resighted 6380 as far down coast as Hopkins Marine Station. During the past couple years she has been observed foraging primarily on mussels and crabs, but spotters have also occasionally recorded her eating urchins, worms, sand dollars, and abalone. Yesterday (04Jan2019), an observer (PC) saw her foraging on crab near the coastguard pier.

Within the last week or so, MBA has received calls reporting her as hauled out on the docks near the coast guard boat slips in Monterey harbor. She has been known to haul-out in this area, but usually under not on the docks. When MBA staff responded to these reports, her overall appearance, condition, and location did not seem to warrant capture. Karl Mayer responded to another call from the public on Wednesday, but he found her in the water, wrapped in kelp and difficult to assess. He may be able to provide you with more details if needed.

GROSS DIAGNOSES

1.) Cardiomyopathy, subacute/chronic, char. by:
-Mild myocardial mottling (PHOTO)
-Possible mild cardiac dilation and mild reverse D-shaped heart (PHOTO)
-Pale, opaque left atrial wall (PHOTO)
-Severe pericardial effusion (10 ml)

1a.) Left and right heart failure, subacute/chronic
-Marked diffuse hepatomegaly (2x normal size) & congestion (PHOTO)
-Marked serous peritoneal effusion (Aerobic culture pending) (PHOTO)
-Marked dilation and fluid-distension of peritoneal lymphatics (PHOTO)
-Marked perihilar edema, hilar lymphadenopathy & peri-hilar septal pulmonary fibrosis, with moderate septal edema of more distant lung fields (PHOTO)
-Marked multi-organ congestion (PHOTO)
-Mild serous pleural effusion
-Moderate diffuse venous dilation
-Mild pleural venous shunting
-Marked pericardial effusion (10 ml)
-Moderate red-tinged foamy fluid in airways (PHOTO)

2.) Possible end-lactation syndrome
-Stage 5 female
-Severe emaciation (No adipose, marked diffuse muscle atrophy) (PHOTO)
-Subacute nose wound (large pink/white) (PHOTO)
-Mammary tissue visible but not lactating (trace mild in teat sinus) (PHOTO)
-Ovaries: 5 CAs, one possible late follicle/early CL left ovary, & possible focal mild post-ovulatory hemorrhage right ovary (PHOTO)
-Placental scars left & right uterine horn (PHOTO)
-Coat mildly dry/coarse

3.) Gastric erosions and melena, severe

4.) Brain diffusely light tan, but not enlarged, herniated or congested (R/O SA/chronic DA damage in CNS on histopathology) (PHOTO)

5.) Mild multifocal post-surgical complications:
-Focal mild incision abscess/focal dehiscence with exterior draining tract, caudal end of most recent ventral midline surgical wound, with mild secondary perilesional matting of pelage due to proteinacious fluid leakage (Aerobic/anerobic culture pending for incision and right inguinal LN-PHOTO)
-Mild edema of peri-surgical subcutis (PHOTO)
-Ventral surface of abdominal wall linea closure is slightly bunched, with approx. 3 mm, minimally-degraded end of suture material protruding through ventral midline closure of linea alba into peritoneal cavity (PHOTO)
-Ventral omentum near greater curvature of stomach: Focal firm mass of necrotic tissue (omentum +/- omental adipose, pres. pending histopathology) associated with focal stellate pattern of tissue bunching, with multifocal perforation of the ventral leaf of the omentum (Possible instrument removal site?) (Histology pending-PHOTO)
-VHF transmitter entrapped in omental bursa, instrument located at outer edge of bursa, very loosely fixed, mildly boloed/twisted (~360 degrees) and loosely wrapped around several loops of intestine (affected intestine appeared WNL and viable at the time of death (PHOTO)

-Hx possible partial TDR extrusion from falciform ligament into the peritoneum, per 10/18 surgical notes

INCIDENTAL:

1.) Possible discrete branchial cleft cyst (congenital remnant of gill) on outer wall of thoracic esophagus (Histology pending-PHOTO)

2.) Mild intestinal Corynosoma

3.) Teeth fair condition (PHOTO)

4.) Mild nasopharyngeal acariasis (~10 adults/cigars only) with associated mild/moderate catarrhal exudate

5.) Multifocal white pulmonary pleural spots (Same as #3 [mites] or related to cardiac failure? (Histopathology pending)

6.) Mild mitral valve endocardiosis (PHOTO)

7.) Left 12th rib at costochondral junction: Focal cartilaginous proliferation

8.) Mild dehydration

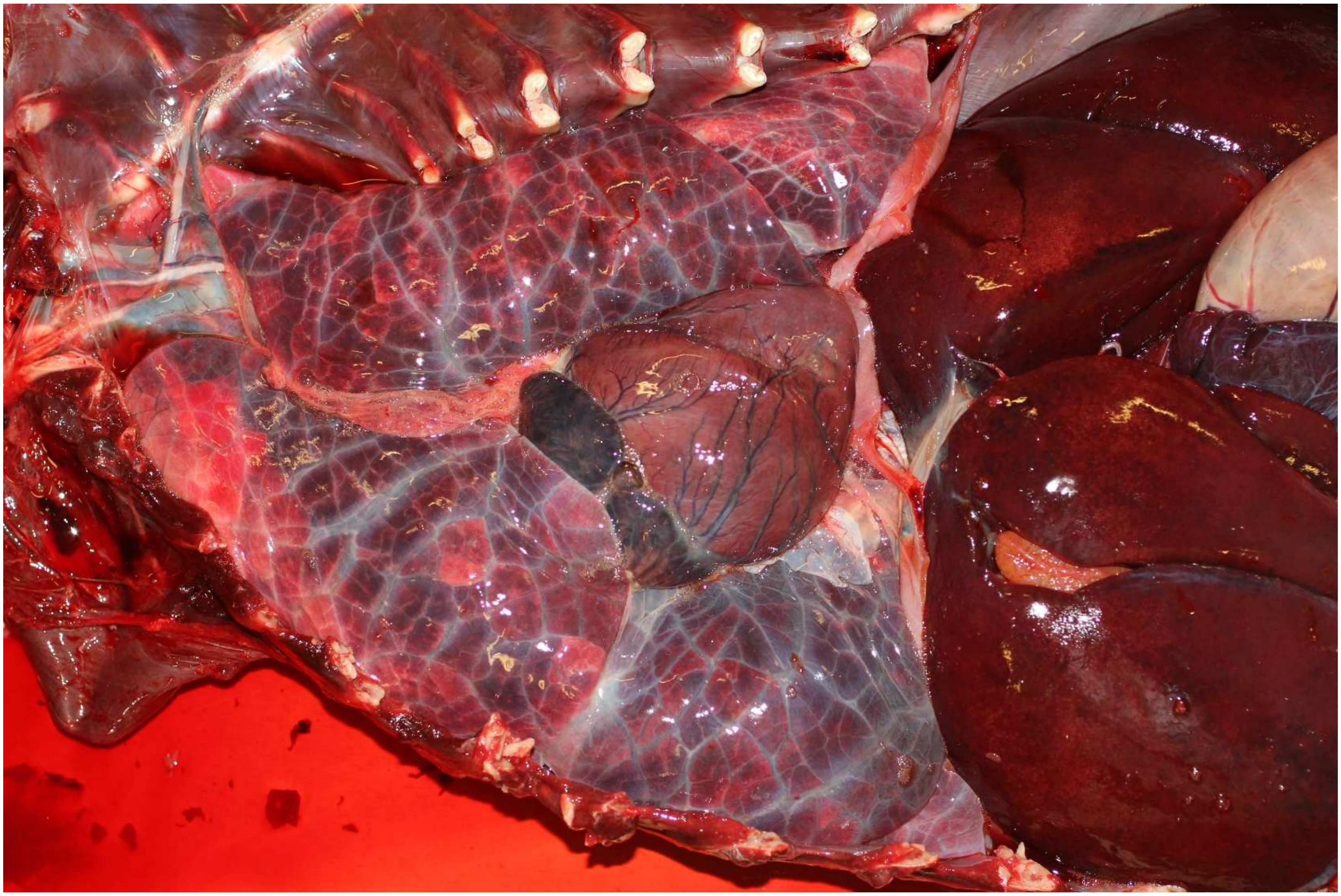
GROSS SUMMARY

Pending results of bacterial culture and histopathology, the primary cause of death was biventricular heart failure secondary to SA/chronic cardiomyopathy. ELS may also have been a contributing factor. Gastric erosions and melena are considered significant peri-terminal lesions. Based on the diffuse, mild tan discoloration of neuropil, brain histopathology may reveal lesions suggestive of prior domoic-acid-associated lesions, or other brain pathology.

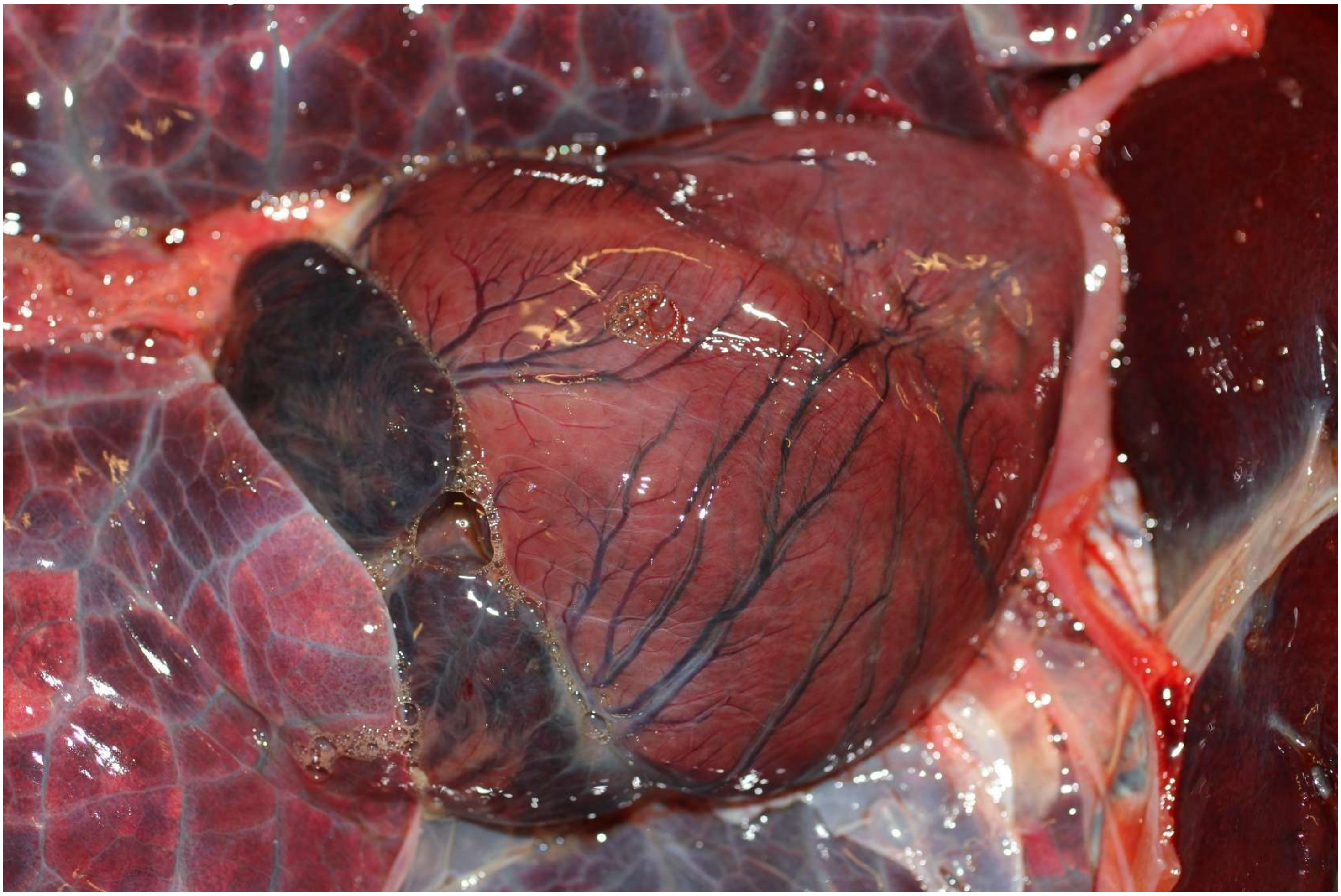
The surgery-associated lesions were concerning, but were considered mild in this case, pending results of bacterial culture and histopathology. Pending discussion with the surgical team and microscopic examination, the focal omental mass and associated omental holes could be a site of previous surgical removal of an instrument from the omentum. However, per the clinical history, TDR placement in this animal was in the falciform ligament, so this finding is a bit unexpected.

Completed:
Gross necropsy
Gross photos

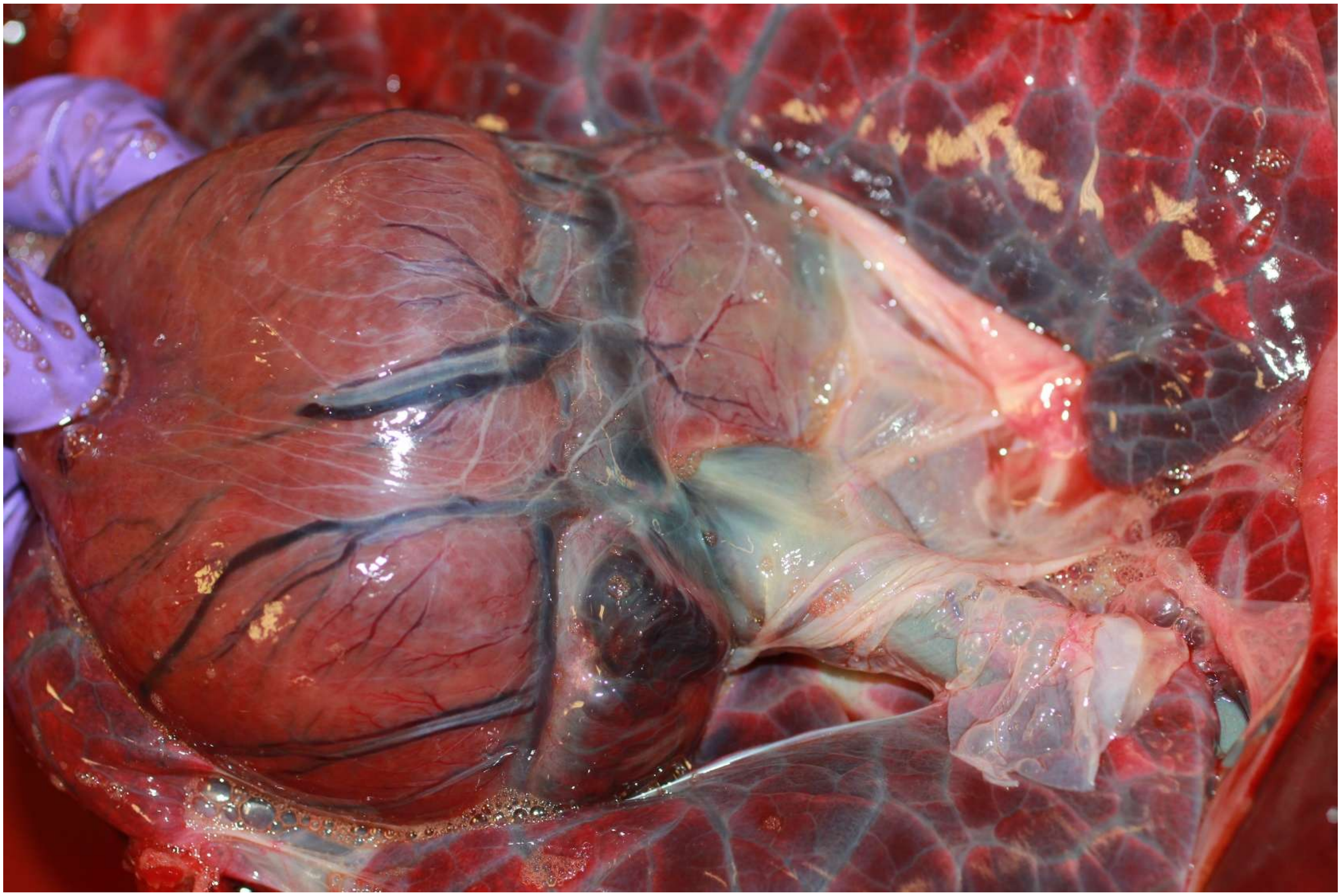
Pending:
Bacterial culture (Ventral midline draining tract at Sx site, R inguinal LN, peritoneal fluid)
Histopathology



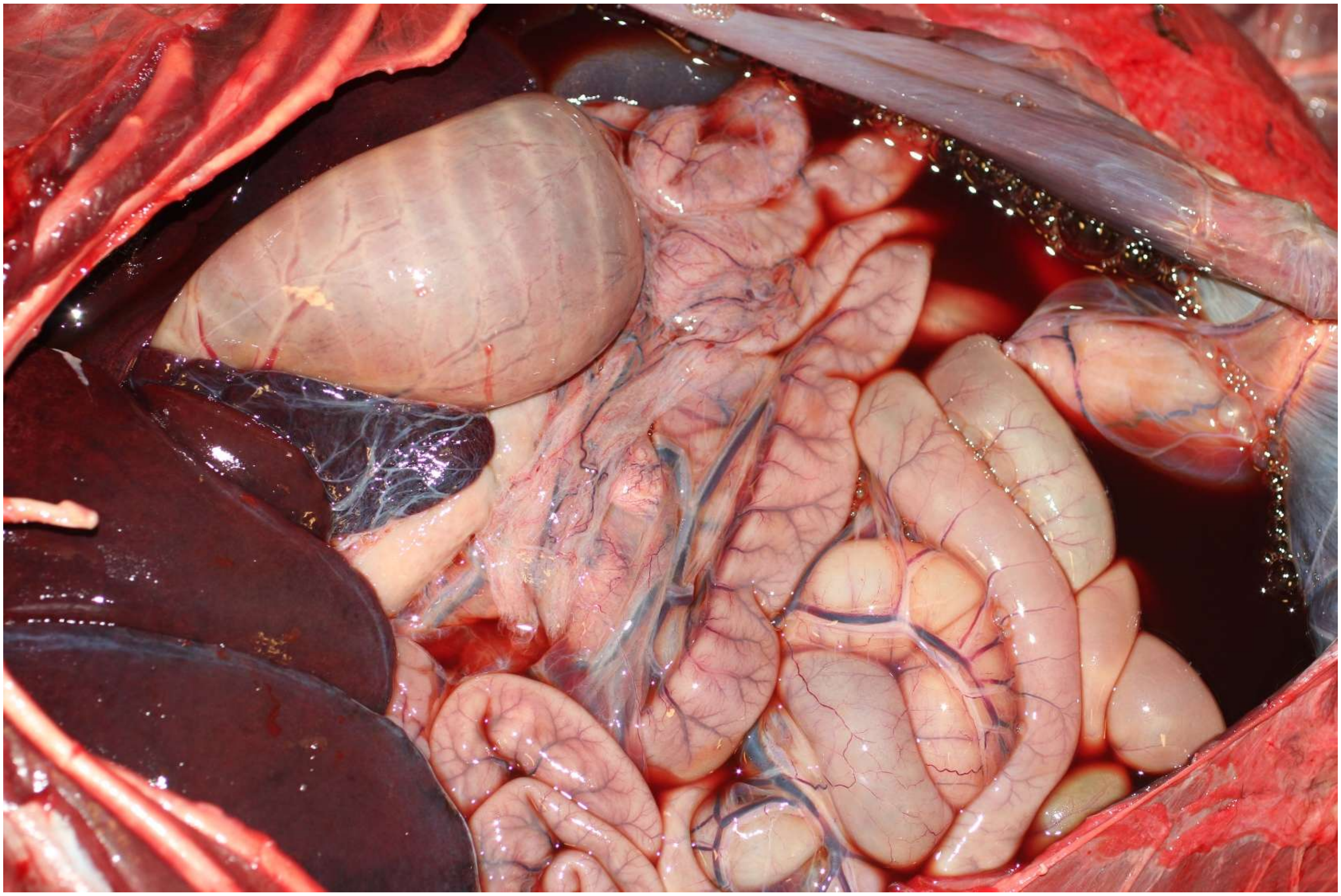
Mildly enlarged, reverse D-shaped heart, hepatomegaly & congestion & pulmonary septal fibrosis (cardiomyopathy with secondary left & right heart failure)



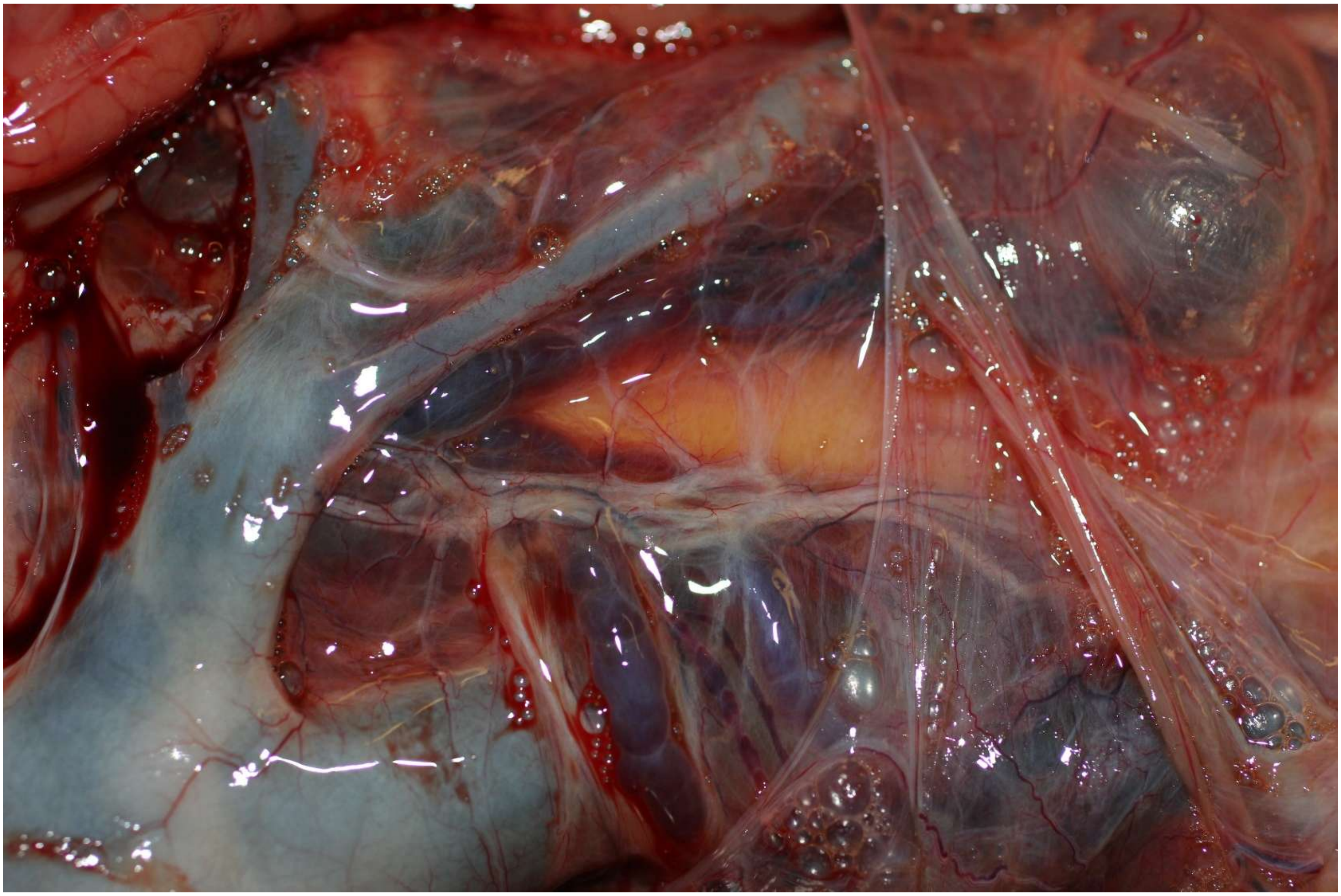
Closer view of ventral cardiac surface, showing reverse D-shape of heart (when viewed from above, indicative of right-sided cardiac dilation), & diffuse myocardial pallor & mottling (cardiomyopathy)



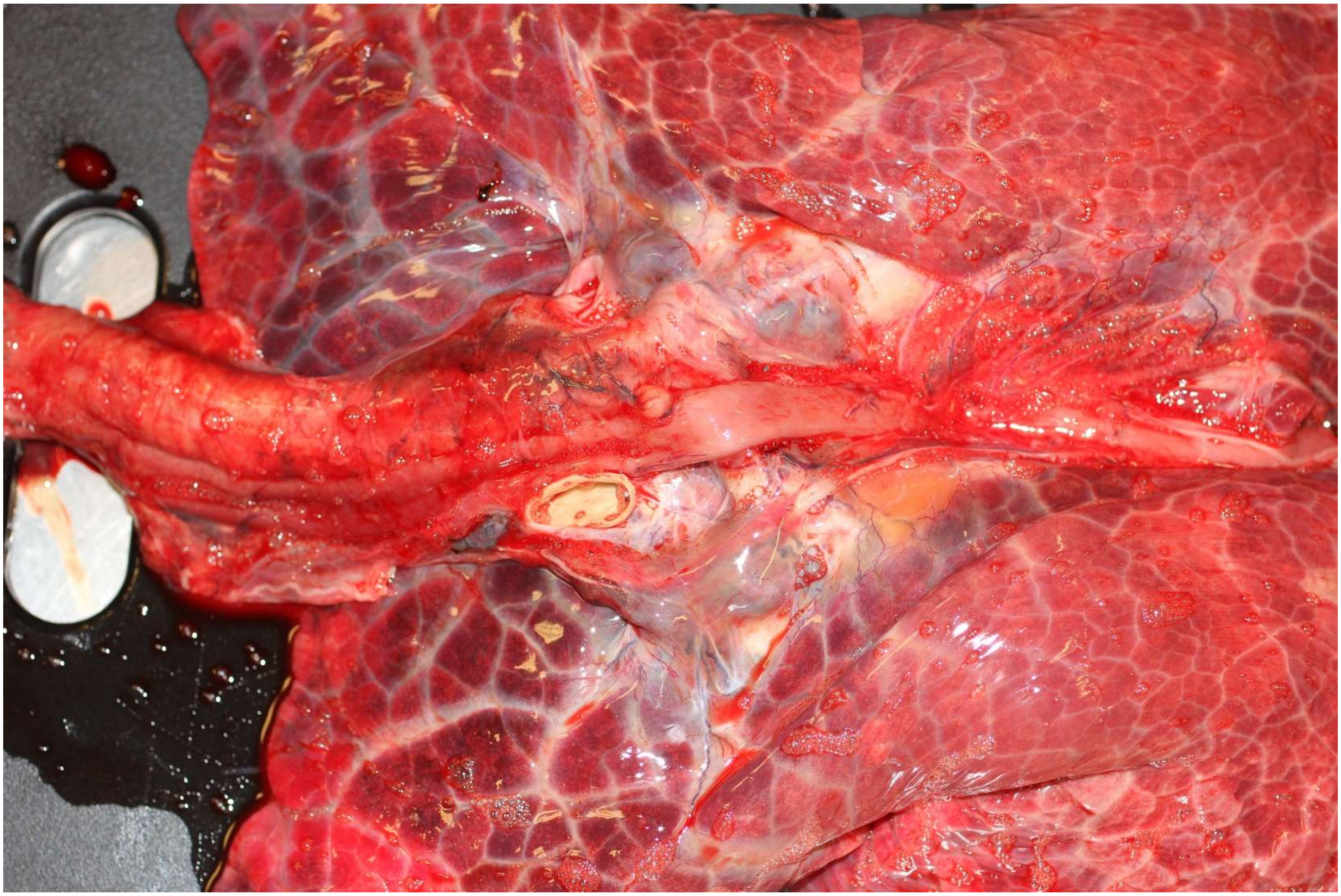
View of dorsal cardiac surface, showing myocardial mottling/pallor, dilation of coronary veins and pale to translucent left atrial wall



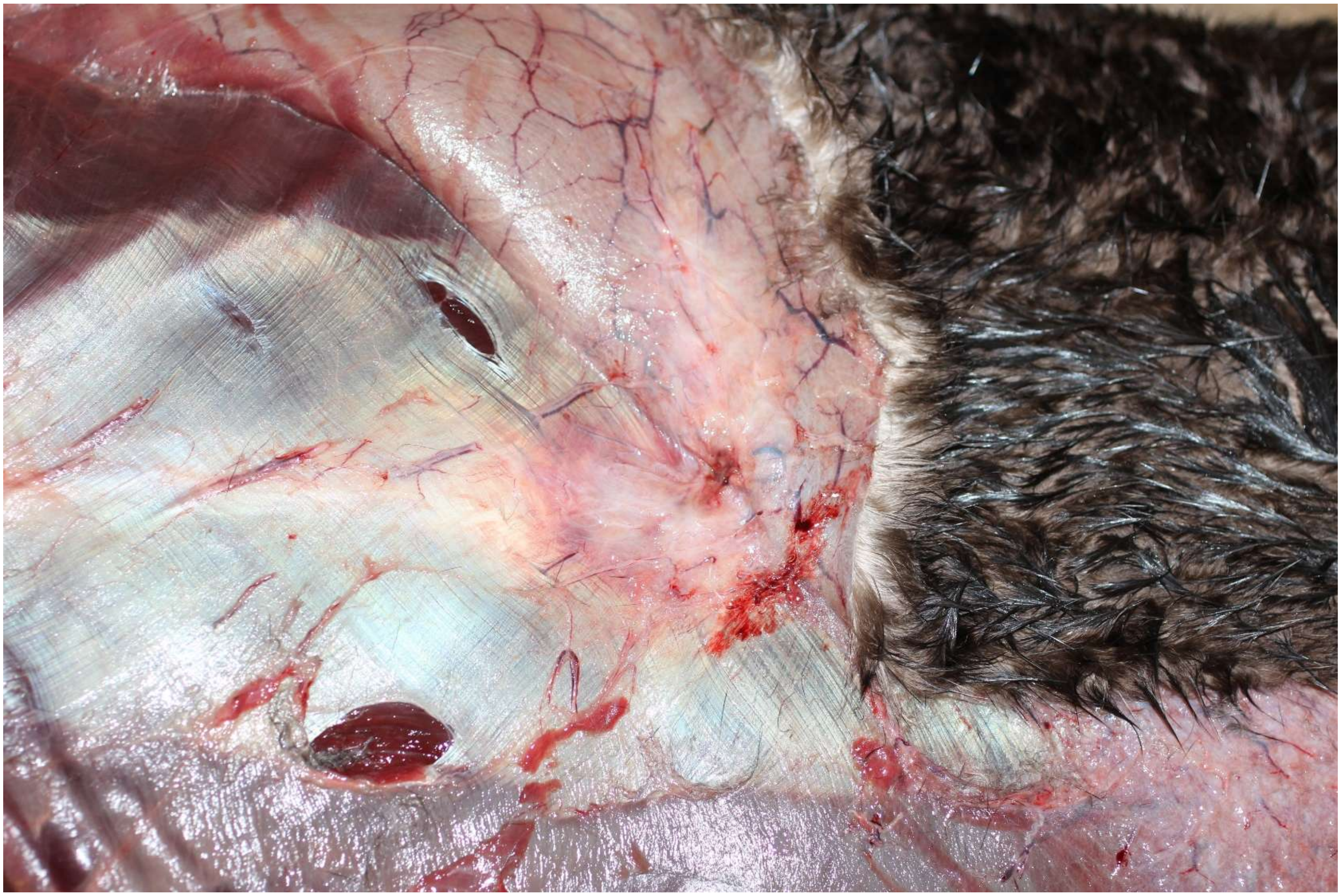
Marked hepatomegaly & congestion, and marked serous peritoneal effusion (right heart failure)



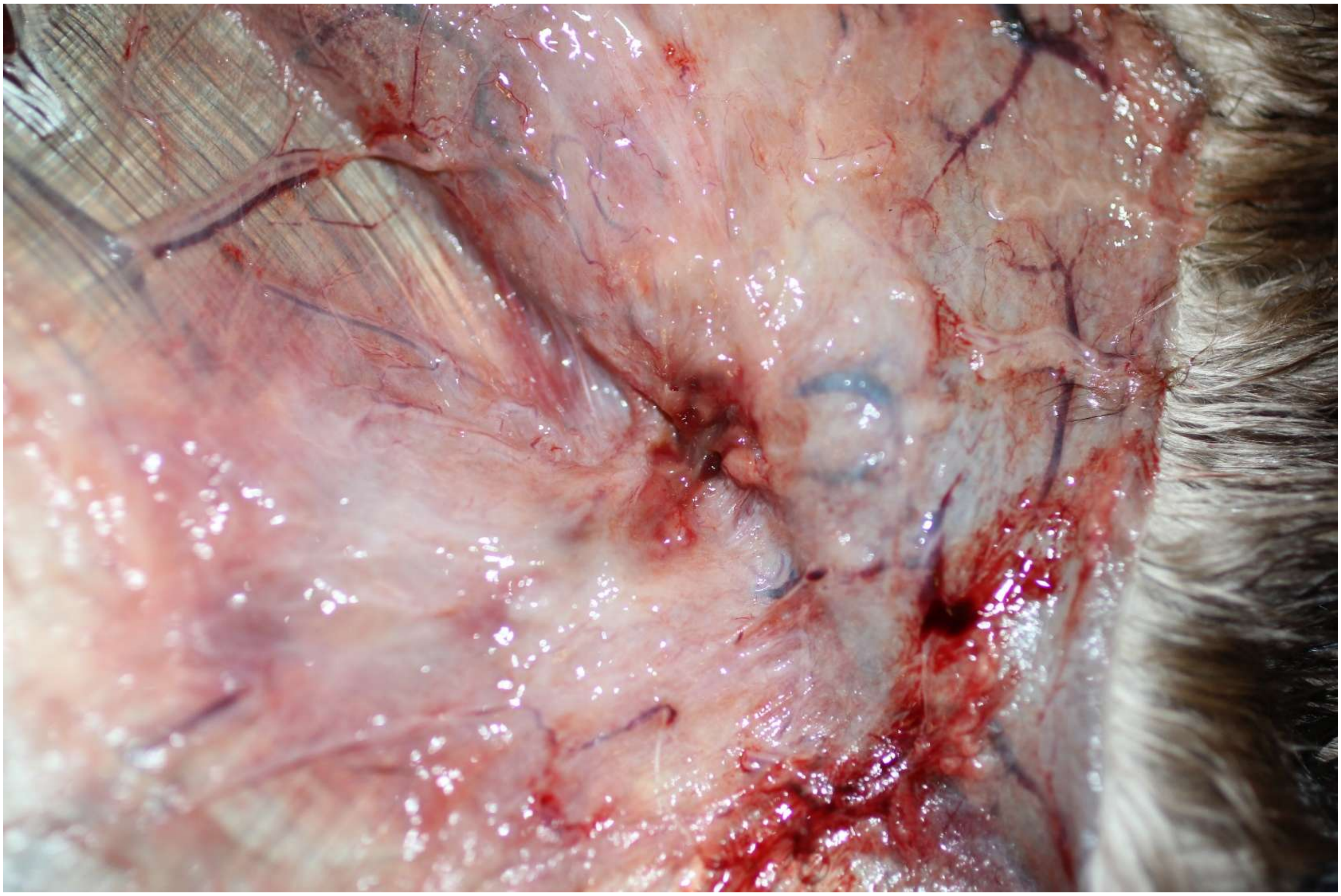
Faschial edema & marked fluid distension of peritoneal lymphatics (three light purple, linear, jointed-looking structures in image center) secondary to right heart failure



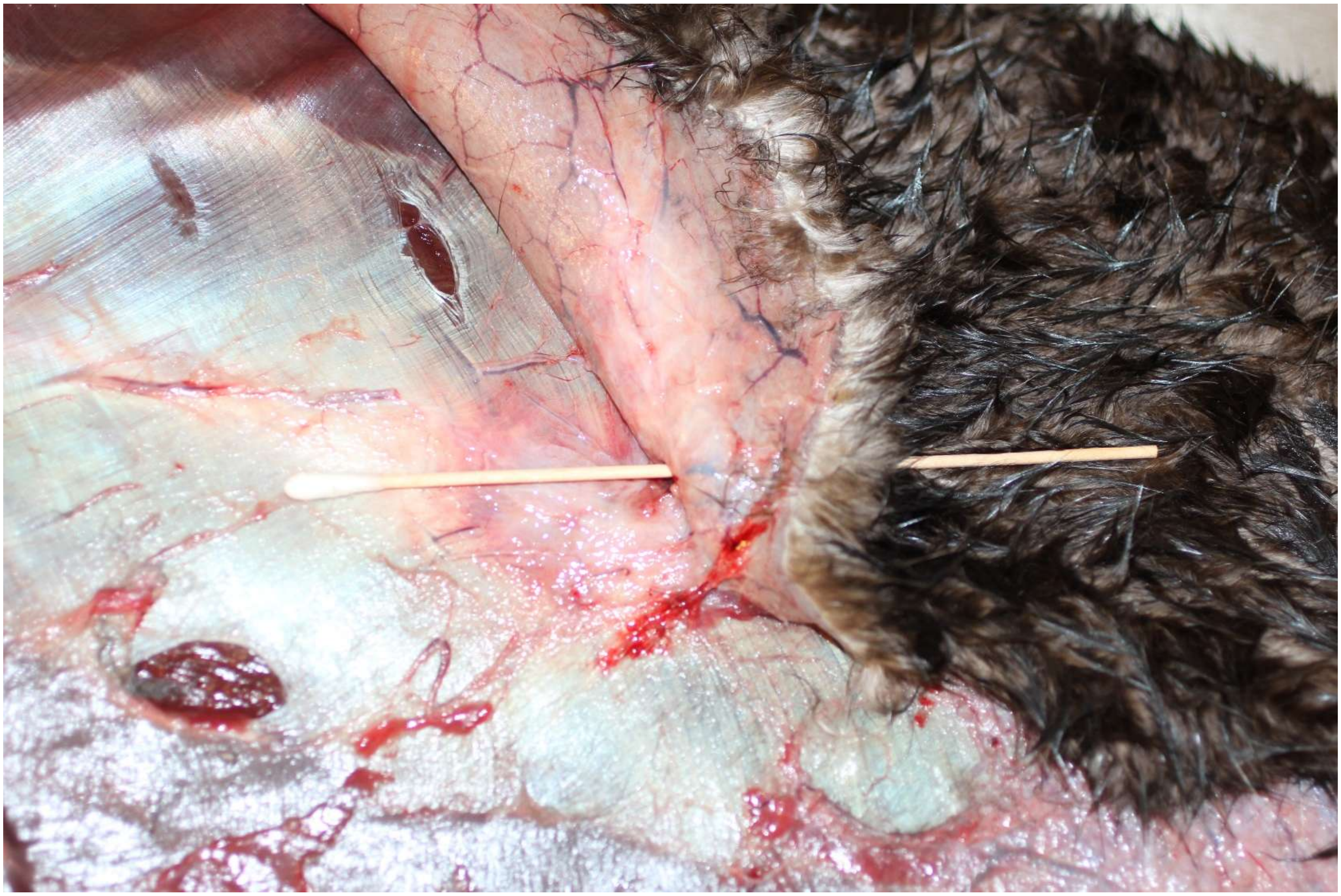
View of hilus (area where the trachea bifurcates and the main bronchi enter the lungs) and the cranioventral lung fields: There is marked perihilar edema, severe hilar lymphadenopathy due to chronic edema, & striking perihilar pulmonary septal fibrosis (chronic left heart failure). The pulmonary septal fibrosis is a tissue response to chronic edema in this region.



There is mild tissue edema at the site of the most recent ventral midline laparotomy. A small area of reddish discoloration is apparent at the caudal edge of the surgical site.

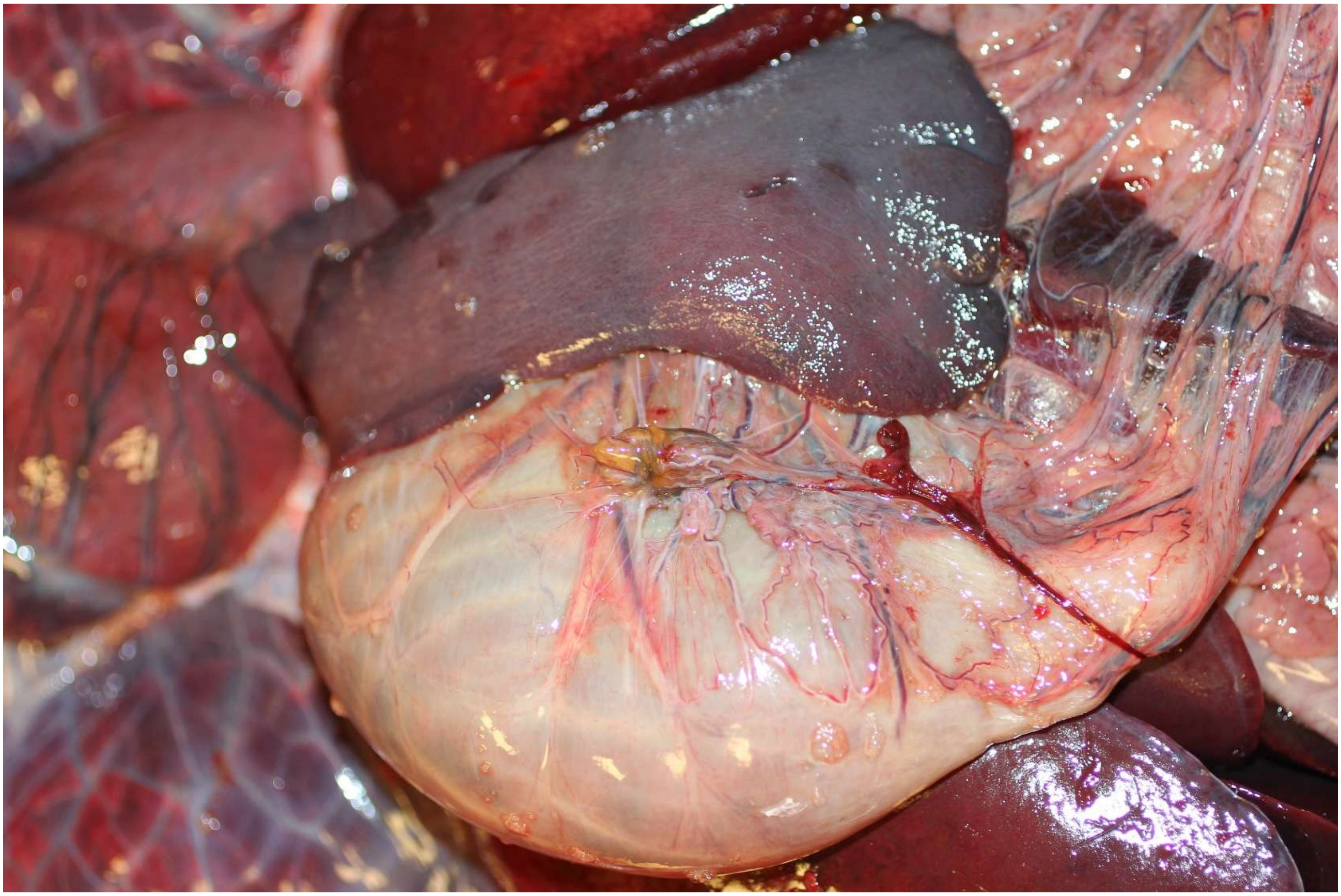


Closer view of the area of tissue discoloration at the caudal aspect of the surgical site. Scant pus and hemorrhage are associated with a small defect in the overlying integument.



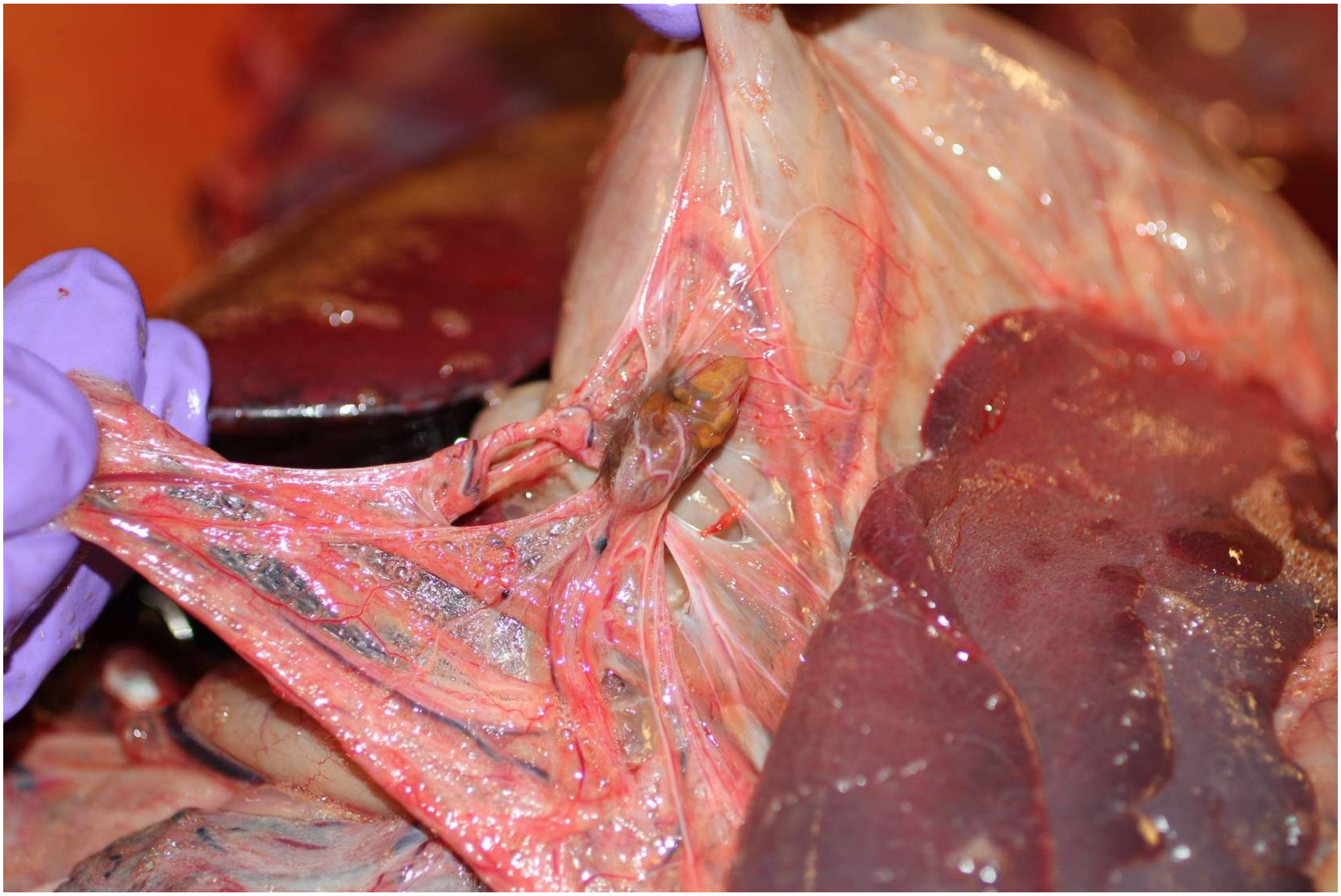
A probe inserted into the integument confirms that the defect shown in the previous photo is patent to the skin surface.

View of the same hole from the skin surface. There is mild matting of the adjacent pelage due to proteinacious fluid drainage from this lesion.

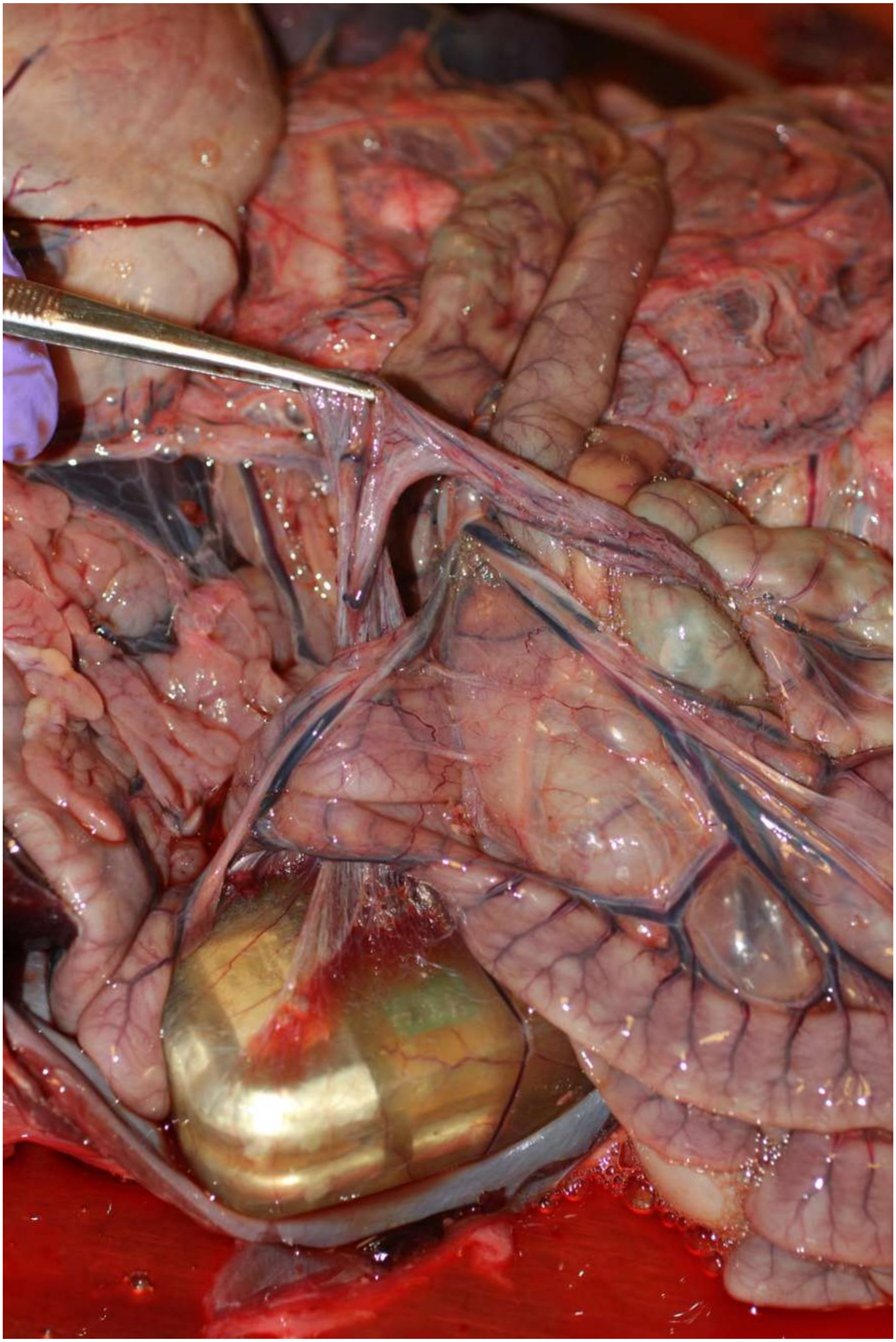


A small, firm, pale yellow mass was located at the center of a region of omental bunching, located in the ventral wall of the omental bursa near the greater curvature of the stomach

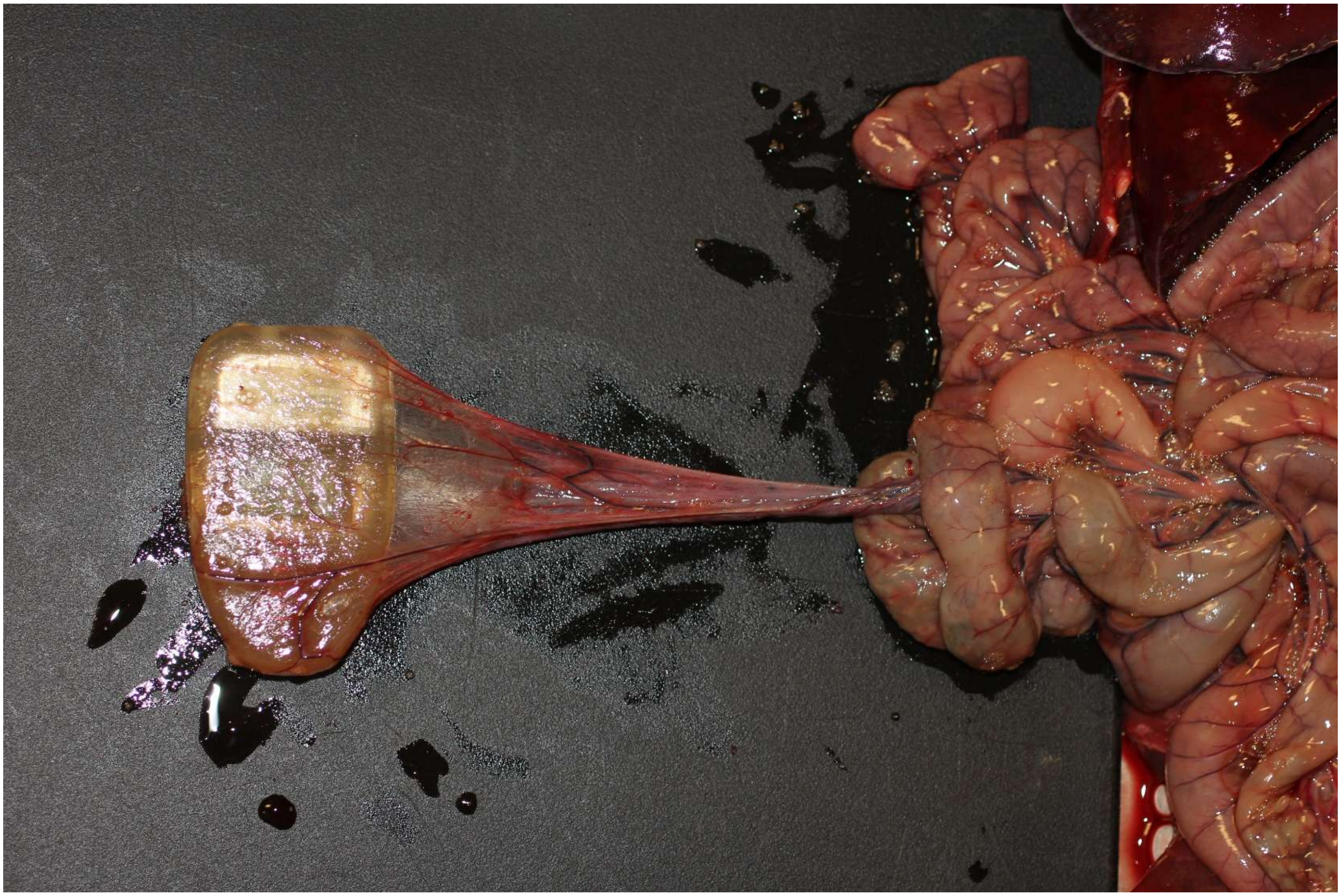
Closer view of the mass, which appears to be composed of degenerating omentum and adipose tissue (fat). The surrounding omental wall appears to be mildly "bunched", & several small holes through the omental wall are apparent in the same area.



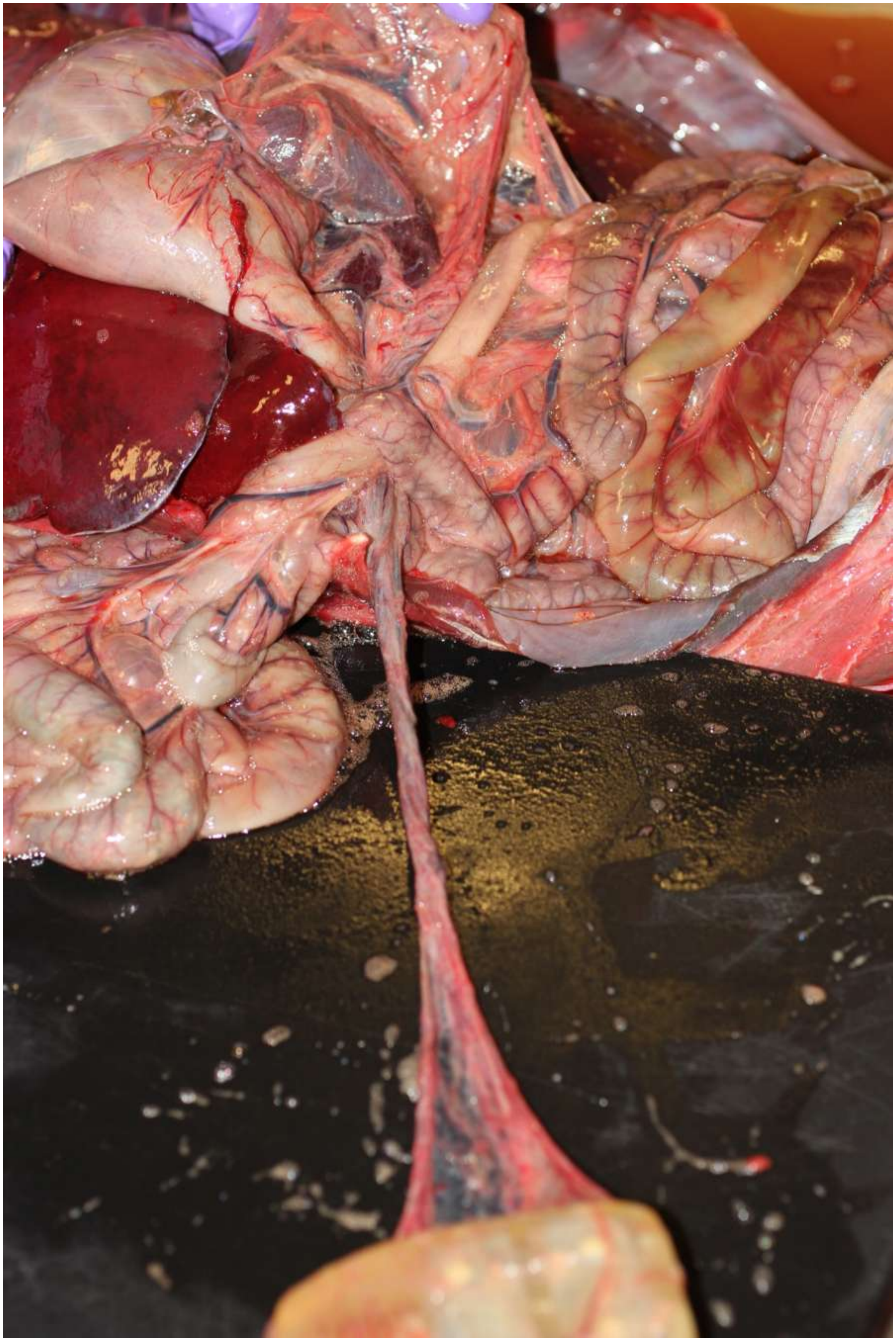
Closer view of the mass, which appears to be composed of degenerating omentum and adipose tissue (fat). The surrounding omental wall appears to be mildly "bunched", & several small holes through the omental wall are apparent in the same area.



The VHF transmitter was inside of the omental bursa at the outer edge of the omental sac, and was associated with mild twisting of the resulting omental stalk



The VHF was lightly adherent to the omental wall in the outer portion of the omental sac. VHF movement produced a long, mildly twisted omental stalk that was loosely wrapped around several loops of small intestine.



In this view most of the lightly entrapped intestinal loops have been unwrapped from the omental stalk. This image shows the mild twisting of the omental stalk, with the VHF within.

A small, discrete, non-communicating cystic structure was apparent on the outer wall of the esophagus. Pending histopathology this could be a congenital branchial cleft cyst (congenital gill remnant) which is interesting, but incidental.

Opened ovarian bursae, uterine horns and vaginal tract. Placental scars, & ovarian corpora albicantia & a possible follicle or early CL are apparent, identifying this as a stage 5 female (reproductive period spanning estrus through pre-implantation pregnancy).

CDFW SEA OTTER NECROPSY REPORT

California Department of Fish and Wildlife
Office of Spill Prevention and Response
Marine Wildlife Veterinary Care and Research Center
151 McAllister Way
Santa Cruz, CA 95060
(831) 469-1719

Sea Otter:	8734-18
UCD PATH:	18S0078
MWVCRC Necrops	18-0020
Report Date:	2/7/2018
Report Status:	Gross

CASE PROFILE

DFG/BRD#:	1213	**Report By:**	Melissa Miller
UON#:	N-1491-12-S	**Necropsy By:**	Miller, Dodd, Greenwald, Reed
MBA#:		**Necropsy Date:**	2/2/2018
Date Found:	2/1/2018	**Condition:**	Fresh
Condition Found:	Fresh	**Sex:**	Male
Live Strand:	No	**Age Class:**	Adult
Euthanized:	No	**Estimated Age:**	4-6 MM
Date Died:		**Location:**	Morro Strand just south of Hwy 41
Total Length (cm):	132	**County:**	San Luis Obispo
Weight (kg):	22.3	**ATOS:**	823
Nutritional State:	Emaciated	**DSOFS COD:**	5
SQ Fat:	Scant	**Histopathology:**	Full
Food in Gut:	Little		

MORTALITY DATABASE CODING

Mortality Code:	TS
Primary COD:	Subacute shark bite, pres.
Sequela 1:	SQ abscess
Sequela 2:	Regional bacterial spread
Sequela 3:	Anemia/ hypovolemia
Secondary COD:	Gastric erosions and melena
Sequela 1:	Anemia/ hypovolemia
Tertiary COD:	Enterocolitis
Quaternary COD:	Acanthocephalan peritonitis, mild

CASE BACKGROUND

1213-12, N-1491-12-S captured 10/2/2012 of Cayucos with Dip Net. Male subadult. Implanted with TDR (1290161) /VHF (164.462), tagged Right: LG 4/5 mba049, Left: PU 1/2 mba061, PIT: SLO2012009 in right inguinal area.

GROSS DIAGNOSES

1. Shark bite, presumptive, subacute/ chronic, severe, characterized by:
   -Multifocal skin and soft tissue lacerations with perilesional granulation tissue and early fibrous connective tissue (most severe over right dorsal hemithorax)

1a) SQ abscess, cellulitis and myositis severe, subacute to chronic: Right dorsal hemithorax: Focal large SQ abscess with marked tissue cavitation, focally extensive encapsulation and purulent myositis

1b) Regional bacterial spread: R axillary and sublumbar LNs: Solid, tan (Reactive) (remainder of lymph nodes mildly/ moderately enlarged, soft and wet-looking due to acute drainage reaction)

1c) Anemia and hypovolemia, moderate

2. Gastric erosions and melena, severe

2a) Anemia and hypovolemia, moderate

3. Possible segmental, severe bacterial enteritis, characterized by:
   -Marked intestinal mural thickening and serosal pleating

4. Acanthocephalan peritonitis, mild (Related to #3?)
   -Mild intestinal Profilicollis

5. Intestinal trematodiasis, severe (Related to #3?)

6. Emaciation

INCIDENTAL FINDINGS:

1. TDR entrapped in omental bursa, not boloed

2. VHF free-floating

3. Surgical scar unremarkable

4. Presumptive viral plaque, ventral midline of tongue

5. Mild intestinal Corynosoma

6. Rectum contained trace mussel shell and small crab carapace fragments

7. Right pinna: Patchy erosions/ alopecia (DDX dermatitis, fight trauma, stranding-associated trauma)

   -Multifocal small white nose wounds, planum nasale

8. Slight congenital umbilical defect (Not open to the peritoneum)

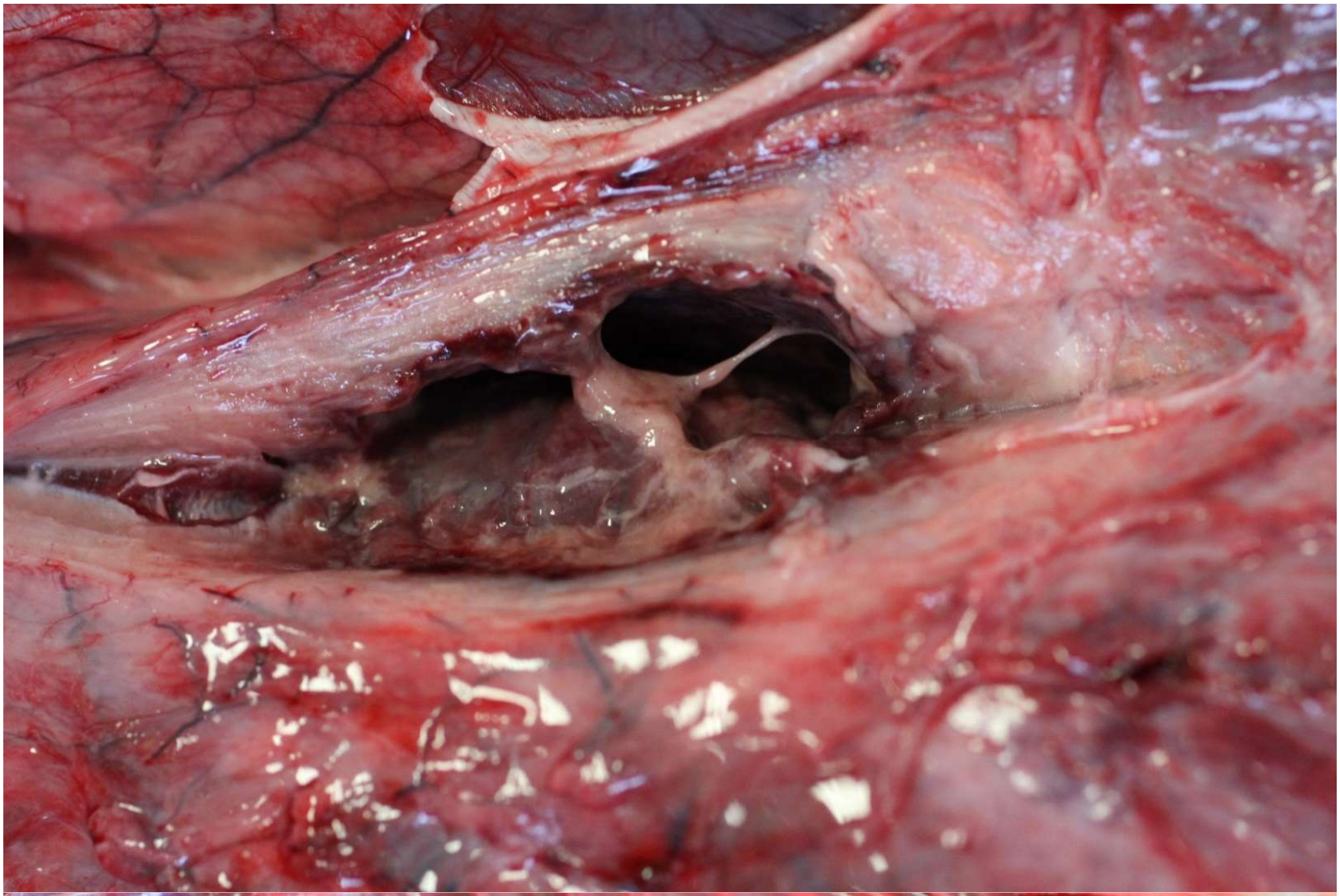
GROSS SUMMARY

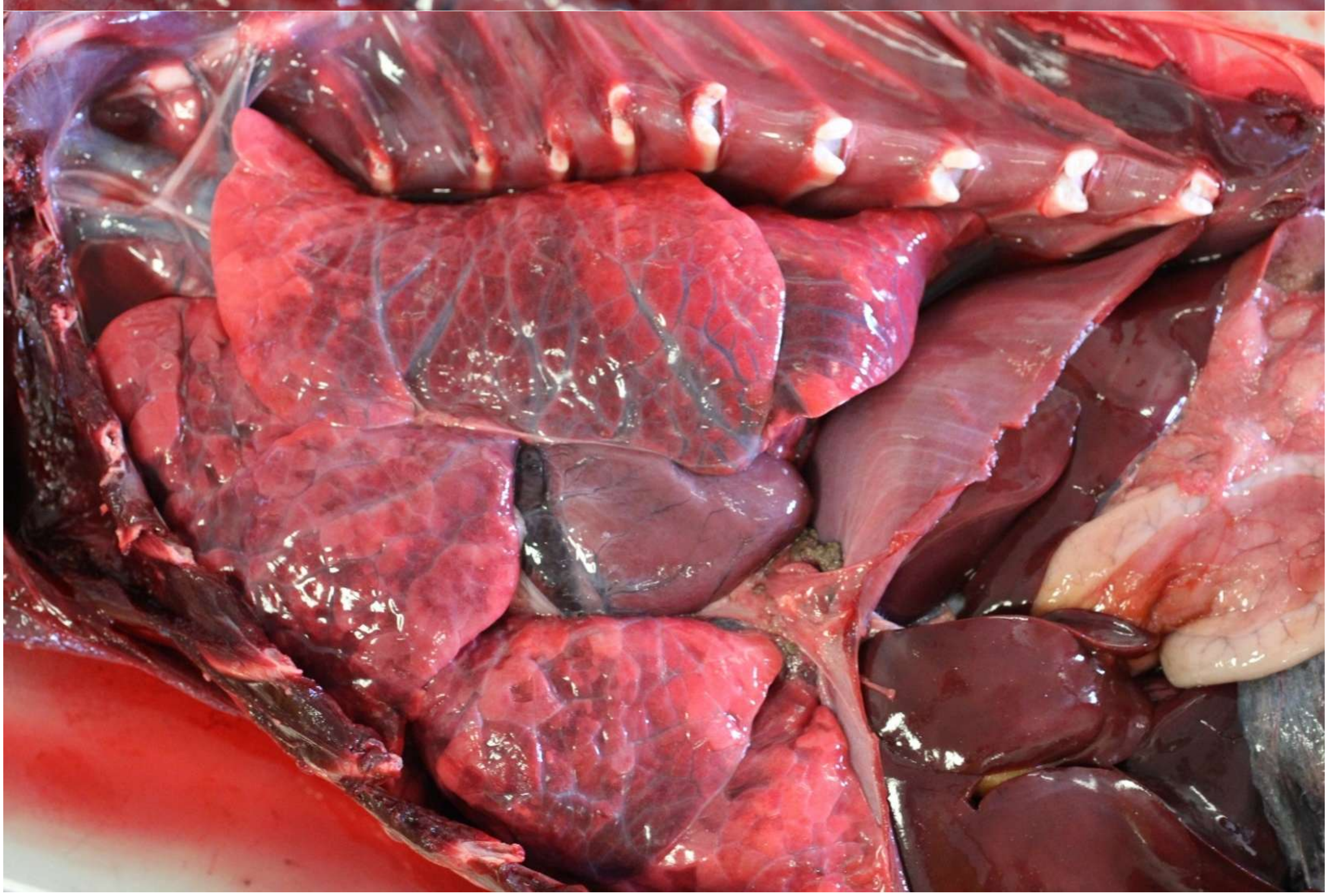
Findings from gross necropsy are consistent with shark bite as the cause of death, although no scratches or fragments of shark teeth were found. Although it is common to observe differential healing of shark bite lesions on sea otters in relation to anatomic location of wounds, the frequency of wound immersion in seawater, wound characteristics, and extent of secondary infection, the adjacent wounds were so widely disparate in the extent of tissue reaction in this case that the possibility of two discrete episodes of shark bite was considered at first, but then discarded in favor of a single shark bite event, with secondary mild postmortem scavenging of tissue through partially healed wounds on the left caudodorsal chest wall. The oldest-appearing wounds were centered on the right dorsal hemithorax: Extensive SQ and intramuscular abscesses, cellulitis and myositis over the right thoracolumbar region were associated with two fully closed and well-healed skin perforations that were neither visible nor palpable on the external skin surface, and were marked by almost fully healed scars on the corresponding dermal surface. These lesions were associated with marked, perilesional tissue granulation and fibroplasia, suggestive of subacute to chronic shark bite wounds. The portion of the abscess directly underlying the healed lacerations was well encapsulated by admixed granulation tissue and FCT. Marked tissue cavitation and expansion of pus into lumbar epaxial muscle distal to the wounds was noted, along with regional matting and flattening of the pelage, likely due to chronic leakage of pus and serum. Abundant light green pus could be expressed from the cavitated areas.

The two, more “acute-looking” full-thickness skin and soft tissue lacerations on the left caudodorsal hemithorax, were likely artificially widened and disrupted postmortem due to scavenging, resulting in postmortem penetration of the chest cavity. This assessment is based on mild postmortem scavenging of the intercoastal muscles in this area, and absence of any apparent perilesional tissue response inside the thorax where sand, seawater and sparse amphipods had accumulated.

Also noted were severe gastric erosions and melena, mild acanth. peritonitis, severe intestinal trematodiasis and marked intestinal mural thickening suggestive of concurrent enteritis. The VHF was free-floating and the TDR was entrapped in the omental bursa. The surgical scar was unremarkable.

Top & Bottom: Dorsal thoracolumbar region showing two wounds over the left hemithorax expanded by mild PM scavenging. Additional skin lacerations along the right hemithorax were closed and almost fully healed. Note regional flattening of pelage due to leakage of pus and serum from the wounds.
Bottom: Same area with skin removed, making the PM scavenging more easily visible. Pus pockets & cavitation from the right thoracic wall wound extended from the left to the right tissue margins.





Top: Extensive encapsulation around abscess on right hemithorax   Bottom: The left caudal chest was artifactually opened to the environment postmortem, with no apparent pleural reaction to influx of sand, seawater and amphipods. Incomplete lung collapse due to sand in bronchi.

Top: Collapsed portal vein (hypovolemia)   Bottom: Severe gastric erosions & melena

Both: Intestinal mural thickening, serosal pleating, mild acanthocephalan peritonitis, free-floating VHF


TDR entrapped in omentum

CDFW SEA OTTER NECROPSY REPORT

California Department of Fish and Wildlife
Office of Spill Prevention and Response
Marine Wildlife Veterinary Care and Research Center
151 McAllister Way
Santa Cruz, CA 95060
(831) 469-1719

Sea Otter:	8735-18
UCD PATH:	18S0096
MWVCRC Necropsy:	18-0021
Report Date:	2/7/2018
Report Status:	Gross

CASE PROFILE

DFG/BRD#:	1307	**Report By:**	Melissa Miller
UON#:	N-1584-13-S	**Necropsy By:**	Miller, Greenwald
MBA#:		**Necropsy Date:**	2/2/2018
Date Found:	2/1/2018	**Condition:**	Adv Decomp
Condition Found:	Adv Decomp	**Sex:**	Female
Live Strand:	No	**Age Class:**	Adult
Euthanized:	No	**Estimated Age:**	5-7 Miller
Date Died:		**Location:**	Salinas River Wildlife Refuge, S of plover sign #22
Total Length (cm):	124	**County:**	Monterey
Weight (kg):	-15.1	**ATOS:**	336
Nutritional State:	Good	**DSOFS COD:**	1
SQ Fat:	Moderate	**Histopathology:**	Partial
Food in Gut:	None		

MORTALITY DATABASE CODING
Mortality Code: 1
Primary COD: Unknown

CASE BACKGROUND

Captured 9/19/2013 at Seal Bend West in Elkhorn Slough as a subadult female 19 kg, 121 cm, age estimate 3 years, VHF 173.496, no TDR.

GROSS DIAGNOSES

Advanced decomposition
Very sandy pelage

1 Unknown cause of death

2 Cannot completely R/O perimortem trauma (unknown type), char. by focal hole over right scapula with extensive postmortem scavenging (DDx PM wear through pelage due to continuous sand abrasion and autolysis, followed by scavenging)

3 Cannot completely R/O perimortem gastric bloat/gastritis?, char. by:
-Stomach markedly dilated, with diffusely black-red gastric serosa and mucosa (No food in GI tract)

-No gastric or splenic displacement

4 Focal area of triangular-shaped hemorrhage on inner surface of aortic trunk (R/O perimortem scavenge wound?)

5 Reproductive stage: Late stage 3 or early stage 4 female (possible pre-wean of pup?), char by:
-Small, symmetrical uterine horns, palpable placental band right horn
-Large (1 cm thick) pink mammary glands, no lactation
-Cervix small and closed, no cervical bruising, no obvious CLs or follicles on either ovary (very decomposed though)
-Vulva not swollen
-No fresh nose wounds

6 VHF transmitter entrapped in omentum and boloed, with firm, tightly twisted omental stalk, no TDR, Sx scar unremarkable

INCIDENTAL:
Mild intestinal Corynosoma

GROSS SUMMARY

Unfortunately due to advanced autolysis, the cause of death could not be determined.

I cannot completely R/O perimortem trauma (unknown type), char. by a focal round hole over the right scapula with extensive postmortem scavenging (DDx PM wear through pelage due to continuous sand abrasion and autolysis, followed by scavenging). Unfortunately advanced decomposition and scavenging prohibit precise assessment of this finding. Because this animal was extremely sandy and the hole in the skin was over bone (scapula), postmortem abrasion/ wear is possible. No tooth scratches or shark tooth fragments were found.

Extensive scavenging of the lungs and cranial chest wall was apparent. Also noted was a small triangular area of mild endocardial hemorrhage on the aortic outflow. There is a low possibility that this lesion is scavenging-associated (eg if the skin laceration was present antemortem and scavenging of the thoracic viscera commenced prior to this animal's death).

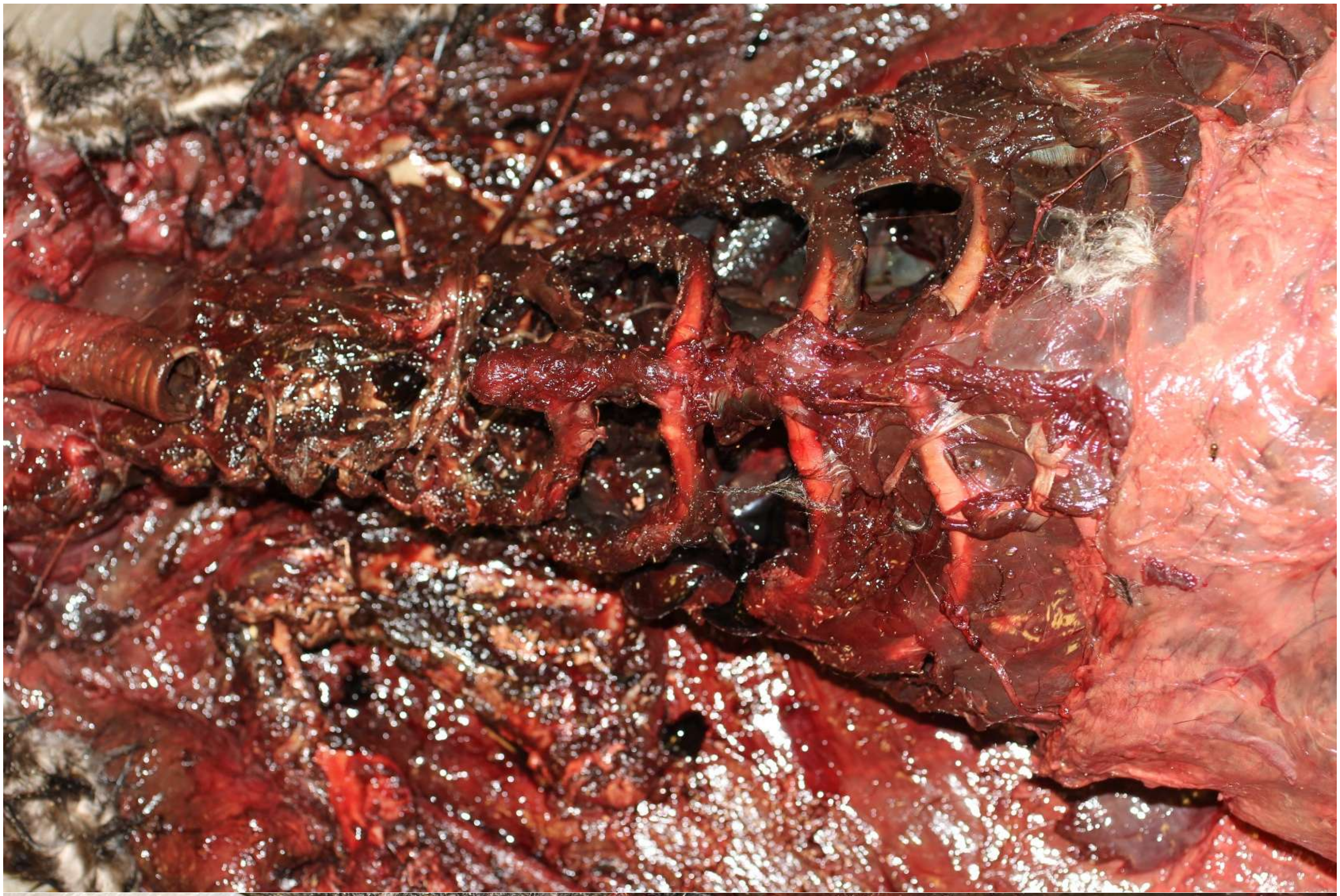
The markedly distended and red-black discolored stomach is also of some concern because it could be indicative of perimortem gastric bloat. However, precise assessment was limited by advanced decomposition. Diffuse, marked red-black discoloration was present on both the serosal and mucosal gastric surfaces, but mainly spared intestine. The stomach and intestines did not contain any food.

Limited histopathology will be performed to further assess the gastric wall, mammary gland, twisted omentum and heart. Because of advanced autolysis, histopathology may not add any additional case insight, but it is worth a try.

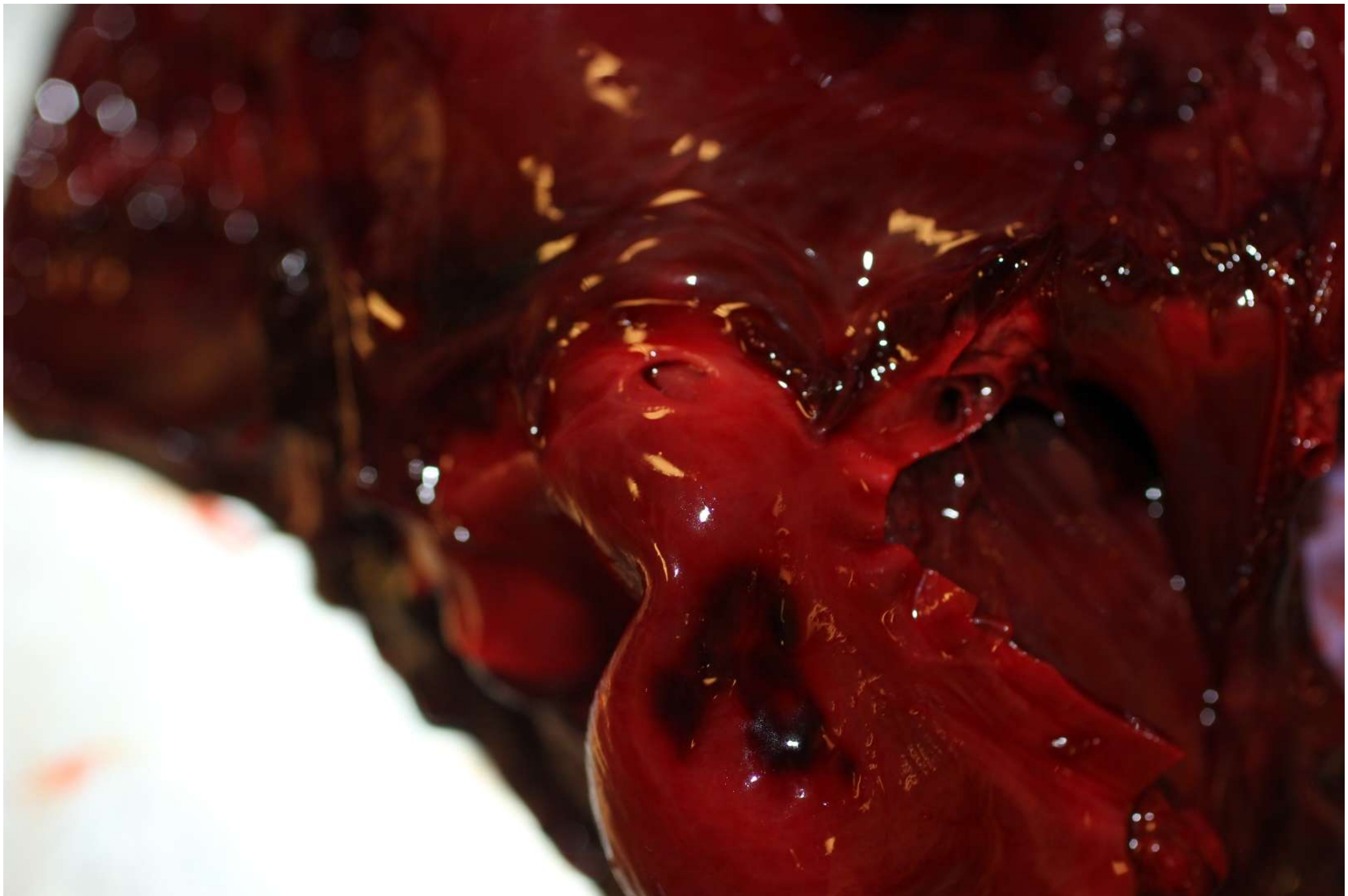
Top: Remainder of flipper tag left flipper Bottom: Hole in left flipper (old tag site)

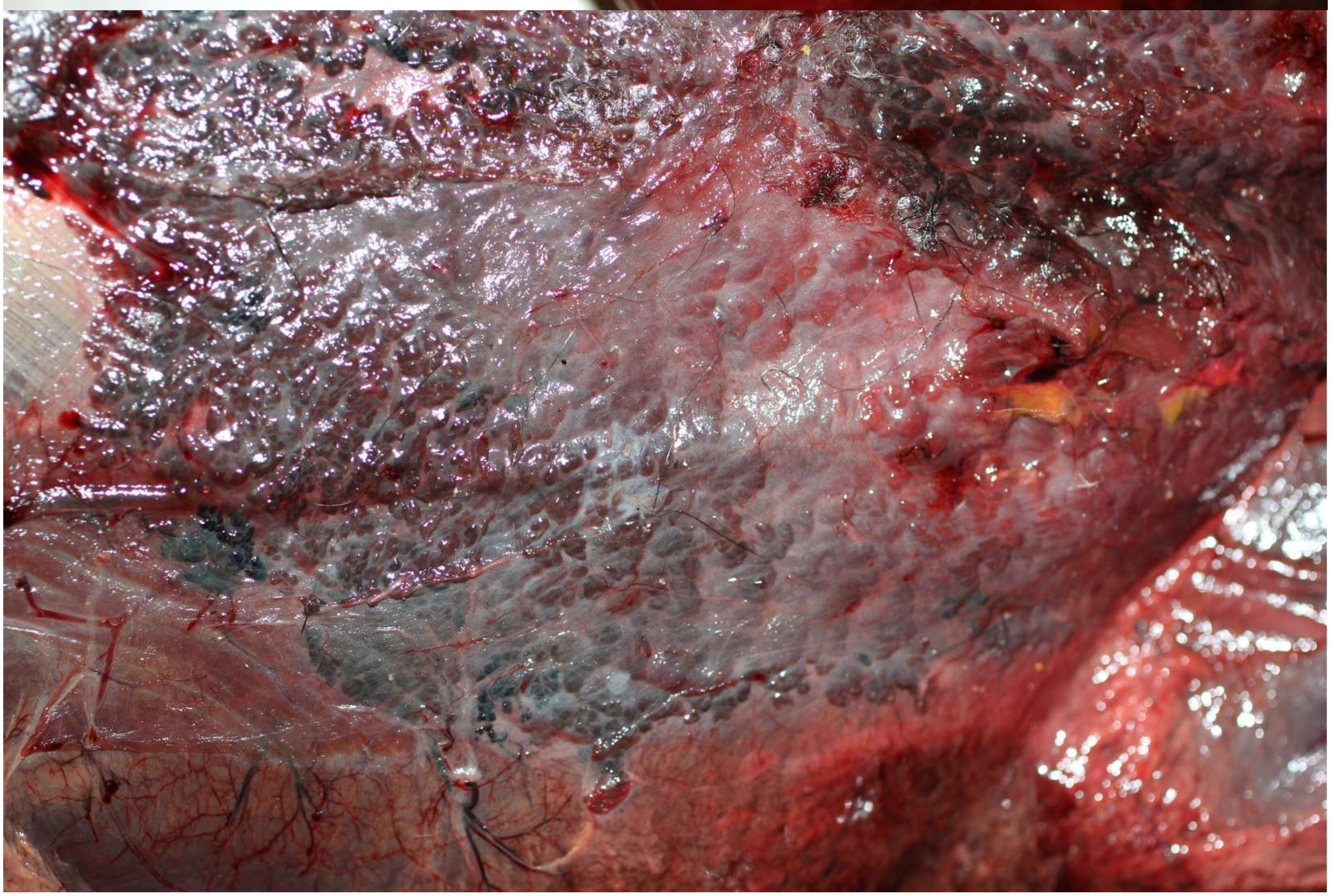
Top: Dentition

Bottom: Hole in skin, right axilla

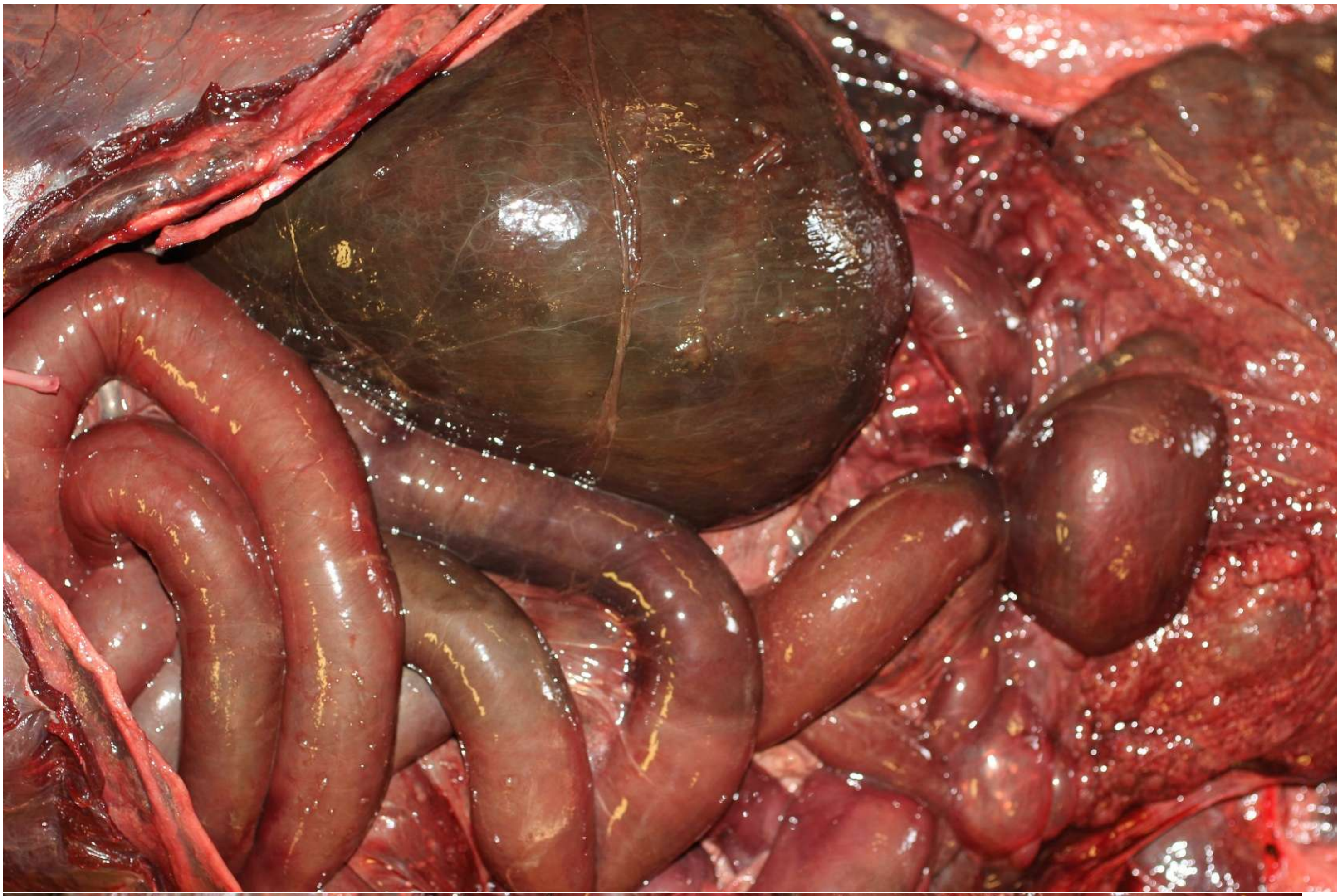
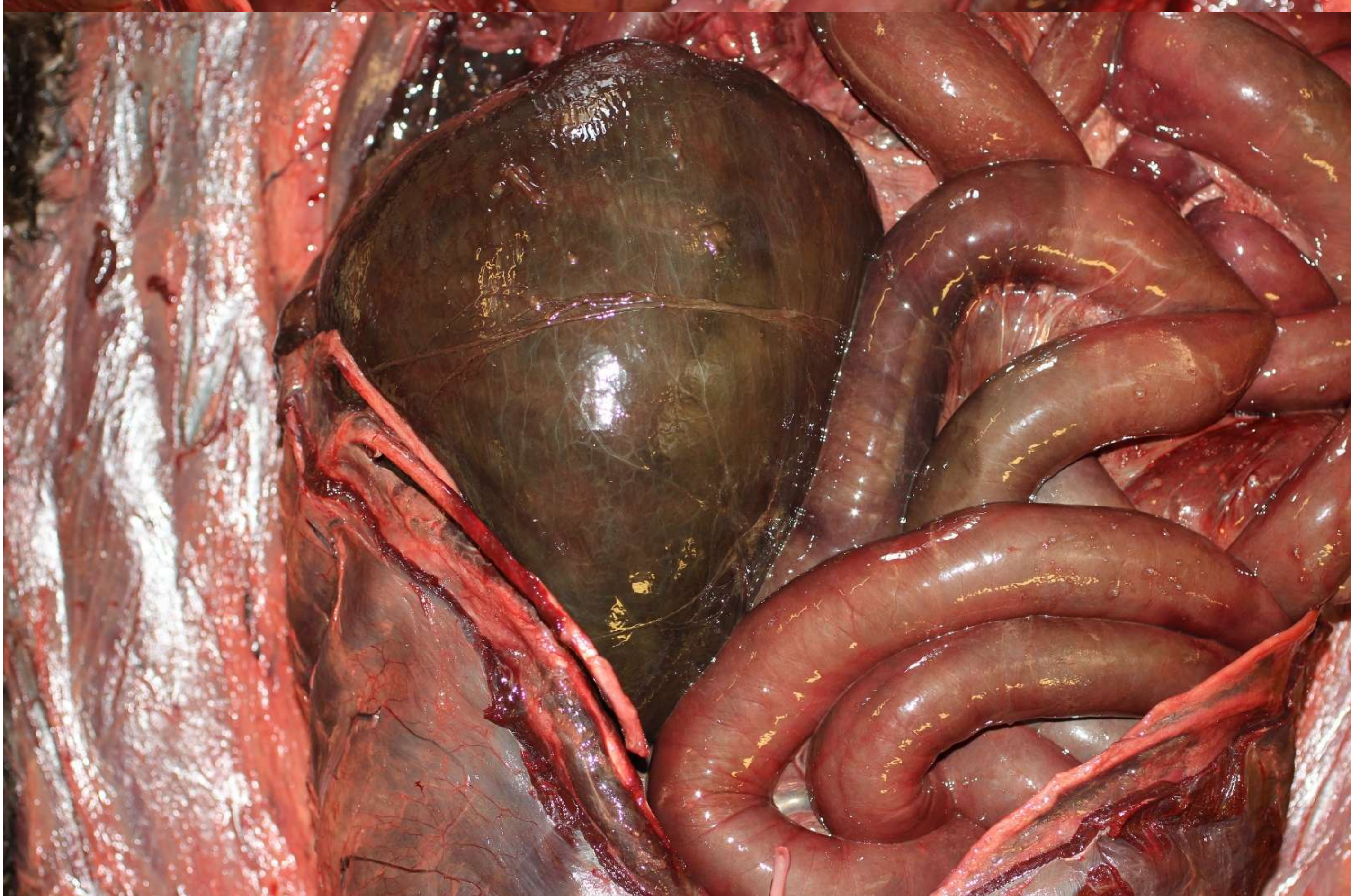


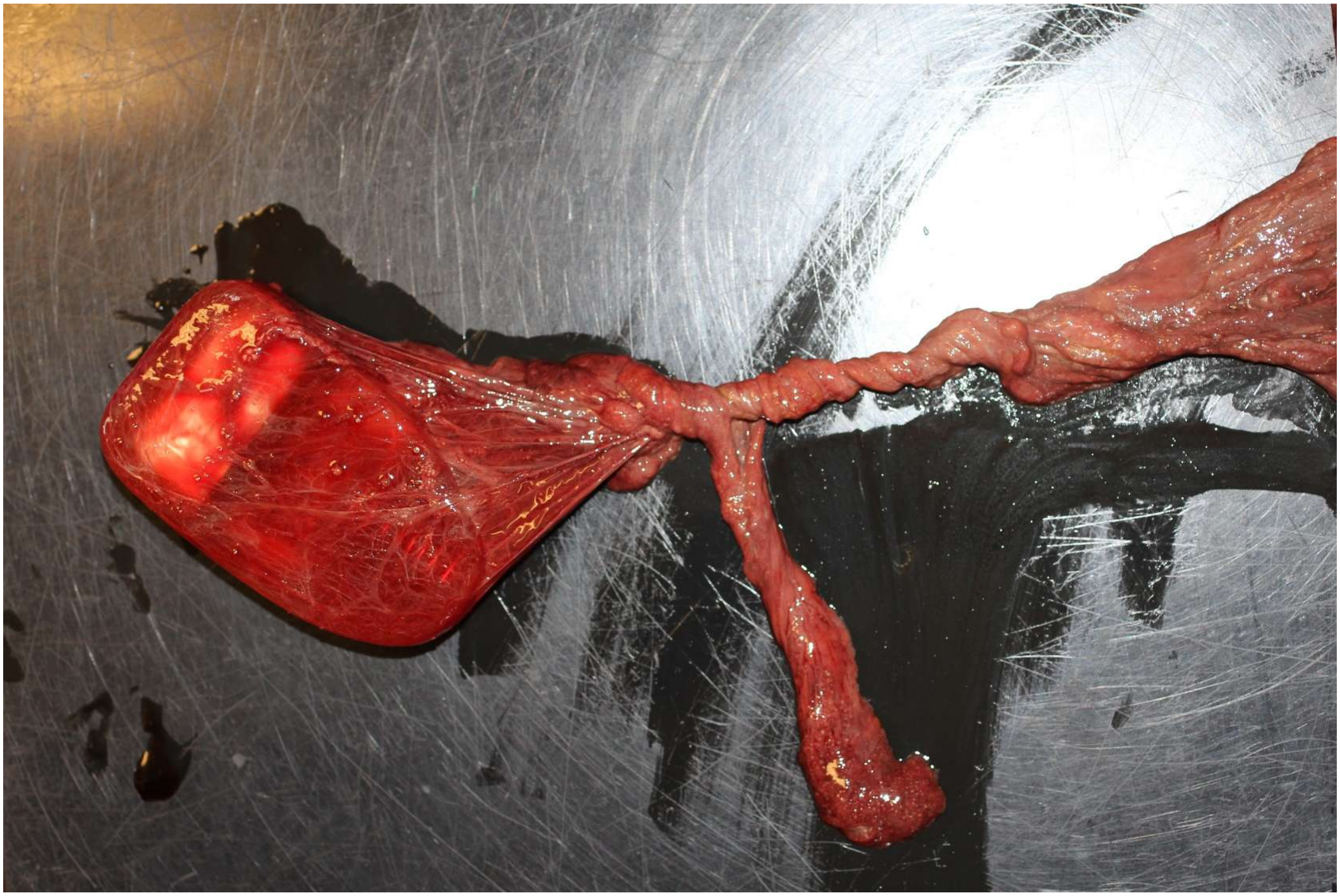
Top & bottom: Extensive scavenging of chest





Top: Focal endocardial hemorrhage aorta
Bottom: Large well-developed mammary glands, no lactation



Both: Markedly distended, red-black discolored stomach without food in lumen (R/O perimortem gastric bloat/ gastritis vs autolysis)



VHF transmitter entrapped and tightly boloed in omental bursa

CDFW SEA OTTER NECROPSY REPORT

California Department of Fish and Wildlife
Office of Spill Prevention and Response
Marine Wildlife Veterinary Care and Research Center
151 McAllister Way
Santa Cruz, CA 95060
(831) 469-1719

Sea Otter:	8744-18
UCD PATH:	18S0106
MWVCRC Necropsy	18-0023
Report Date:	2/13/18
Report Status:	Gross

CASE PROFILE

DFG/BRD#: 1330
UON#: N-1606-14-S
MBA#:
Date Found: 2/10/2018
Condition Found: Fresh
Live Strand: No
Euthanized: No
Date Died:
Total Length (cm): 121
Weight (kg): 17.7
Nutritional State: Good
SQ Fat: Moderate
Food in Gut: None

Report By: **Dr. Melissa Miller**
Necropsy By: MM, ED, FB, CY, AW
Necropsy Date: 2/12/2018
Condition: Fresh
Sex: Female
Age Class: Adult
Estimated Age: 5-7 MM
Location: Del Monte Beach, just N of Casa Verde Condos
County: Monterey
ATOS: 372
DSOFS COD: 11p
Histopathology:

DATABASE CODING

Code11p (PT)
Primary COD
DA
intoxication,
acute/
subacute,
pres
Sequela 1
Sequela 2
Secondary COD
Cardiomyopathy,
A/SA
Tertiary COD
Perimortem
seawater
aspiration

CASE BACKGROUND

23Sept2014 captured off MBA, VHF only 166.022, 18.55kg, 113.7cm TL, estimated at 3 years old by M. Staedler

Here is Yelsi's factsheet. By the time I found her carcass, it was after sunset, so I did not get a very good look at her carcass. She seemed super fresh though, with no obvious trauma.

Yelsi (Yellow SIlver) has been part of the NSF study, but tagged originally in 2014. We generally resight her from Hopkins to Otter Point, but she has been seen as far north as NPS, and as far south as the Great Tide Pool. She forages primarily on kelp crab, fat innkeeper worms, urchins, mussels, and chitins.

She was last seen a couple days ago with her 10 week old pup. I think yesterday, trackers recorded a weak radio resight off Otter Point.

Per Michelle S. update, she had an antemortem Hx of 4 pups observed.

GROSS DIAGNOSES

1. Domoic acid intoxication, acute to subacute, pres. char. by:
   -Acute death with glossy pelage in good nutritional condition
   -No food in GI tract
   -Moderate/ severe multi-organ congestion esp. liver and kidneys (see also #2)
   -Marked diffuse meningeal and neuropil congestion and mild/ mod cerebellar coning
   -Possible multifocal meningeal hemorrhage
   -Hyphema OD (Eye scavenged OS-Mistake in case notes)
   -Scant blood-tinged CSF (Mild dehydration)
   -Urine pale yellow, 50 ml

2. Cardiomyopathy, mild acute to subacute (Same as #2, pres.) char. by:
   -Mild patchy myocardial mottling
   -Mild diffuse venous engorgement, ventricular myocardium mildly and diffusely brown-discolored
   -Probable acute myocardial hemorrhage in papillary muscles of left ventricle
   -Mild peritoneal effusion (20-30 ml)
   -Pericardial effusion, mild (6+ ml)

3. Probable perimortem seawater aspiration (+/- acute cardiac failure), characterized by:
   -Marked diffuse pulmonary edema and pleural effusion (200 ml)
   -Red-tinged fluid in mouth, nose, airways, lungs, stomach and staining hairs around nose and mouth

INCIDENTAL FINDINGS

1. Mid/ late stage 3 female:
   -Large mammary glands, moderate adipose, mild diffuse muscle atrophy/ catabolism
   -Moderate SQ adipose, mild muscle atrophy
   -CA's: Left 2+, right 1+
   -Uterine horns small and symmetrical
   -Placental bands L& R (larger/ most recent is on left)
   -Cervix small, closed, non-bruised, mild vulvar swelling (cardiogenic?)
   -Nose wounds small, white

2. Ventral midline surgical scar unremarkable, VHF free-floating, no TDR

3. Small SQ cyst right lateral neck near retropharyngeal LN (R/O residual branchial cleft cyst on HP)

4. Left nipple mildly bloody, underlying mammary gland normal (Perimortem trauma, pres.)

5. Possible small/ mild viral plaque, ventral tongue

6. Mild intestinal Corynosoma

GROSS SUMMARY

Pending histopathology and biochemical testing, the presumptive cause of death is acute/ subacute DA intoxication with associated cardiomyopathy and terminal seawater aspiration.

The fresh carcass of an approx. 1 week old, acutely dead pup in excellent nutritional condition and with a GI tract full of milk (NOT matching the age of this female's pup) was recovered in the same area 3 days later and was necropsied 2/13/18. Gross lesions for the pup were more moderate, but were otherwise similar to this case. A partial fresh necropsy was performed on that case, including collection of coagulated milk from the full stomach. These two cases will be worked up in tandem.

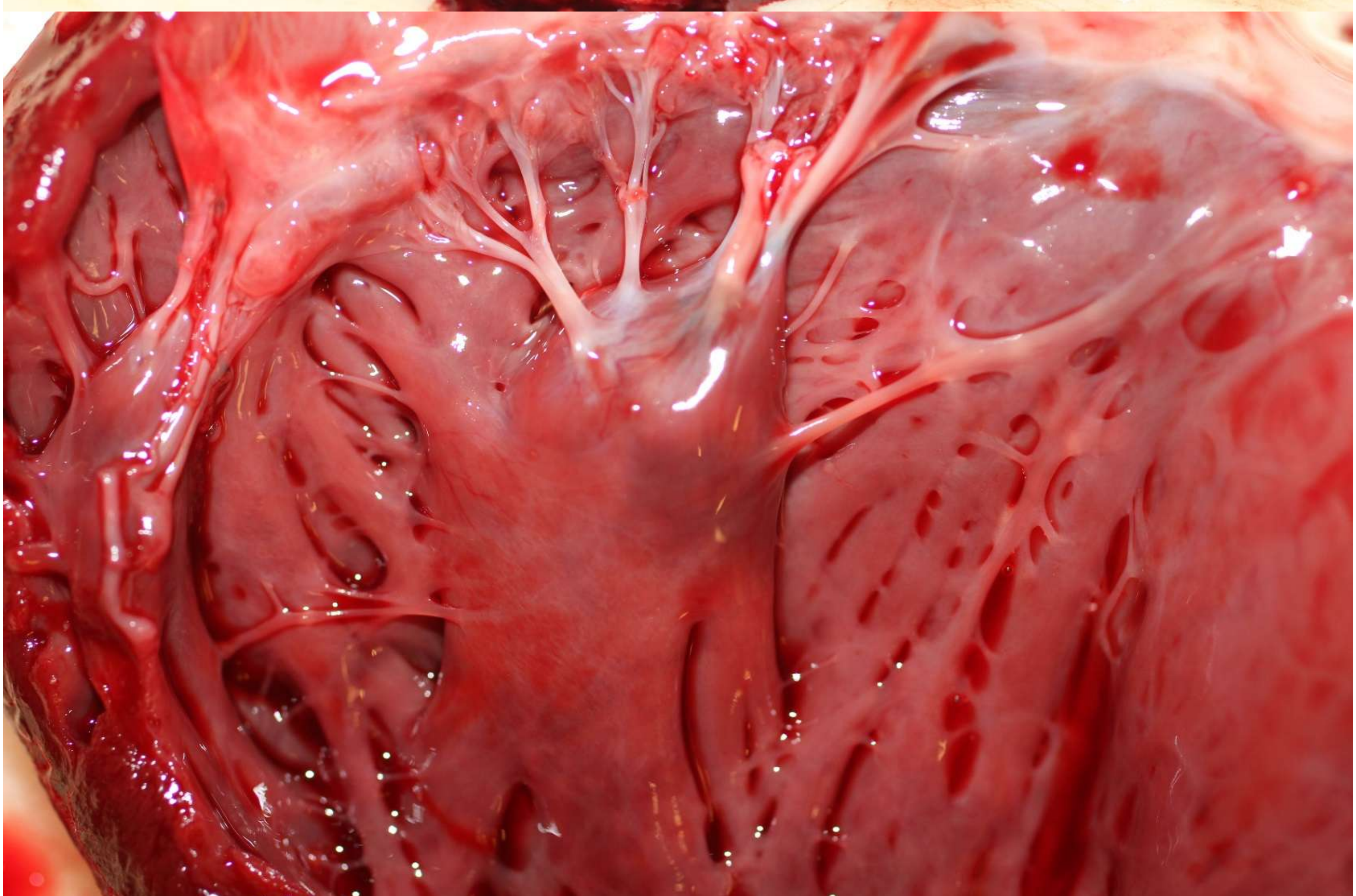
Note: Both animals stranded in an area where a large (approx.. 5 million gallon) sewage spill had occurred approx.. 1 month prior, and where a regional HAB event with STX production and bioaccumulation in shellfish had occurred over the past few weeks. A few birds had also been reported exhibiting neurological disease from this area over the past few weeks. HP and further testing are pending.

Saved:

- Gross photos
- Full sample set frozen and HP
- Demodex & mycoplasma samples
- Hair & whisker, tooth
- Urine, PCF, serum, CSF (drop w/ blood contamination) (No food)

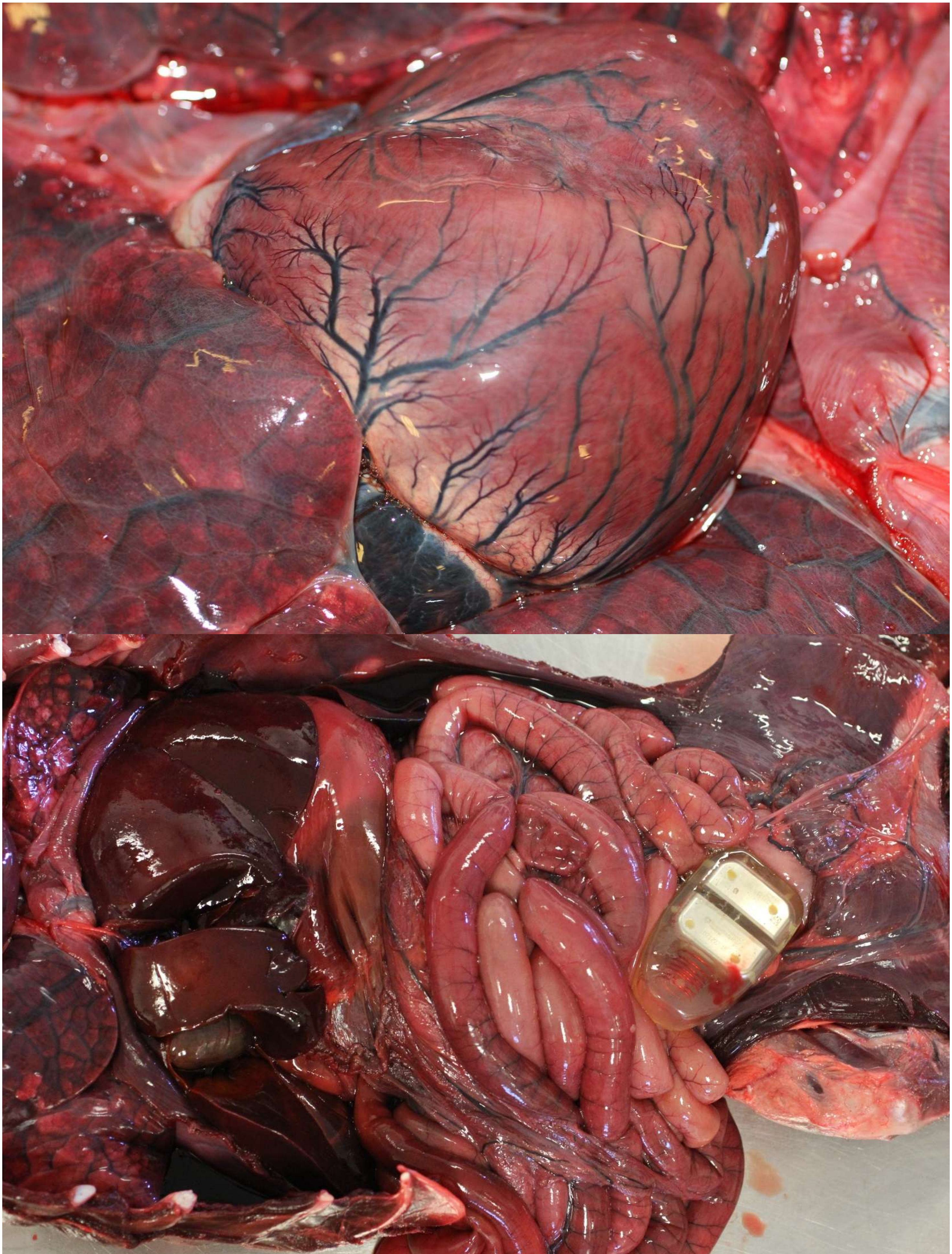
Next steps:

- Examine suspect pup from this animal 2/13/18 (Found fresh dead 2/12/18)
- MM to assist with brain trimming for both (trim in all CVOs)
- Test urine for DA (both if possible)
- Full histopathology x 2

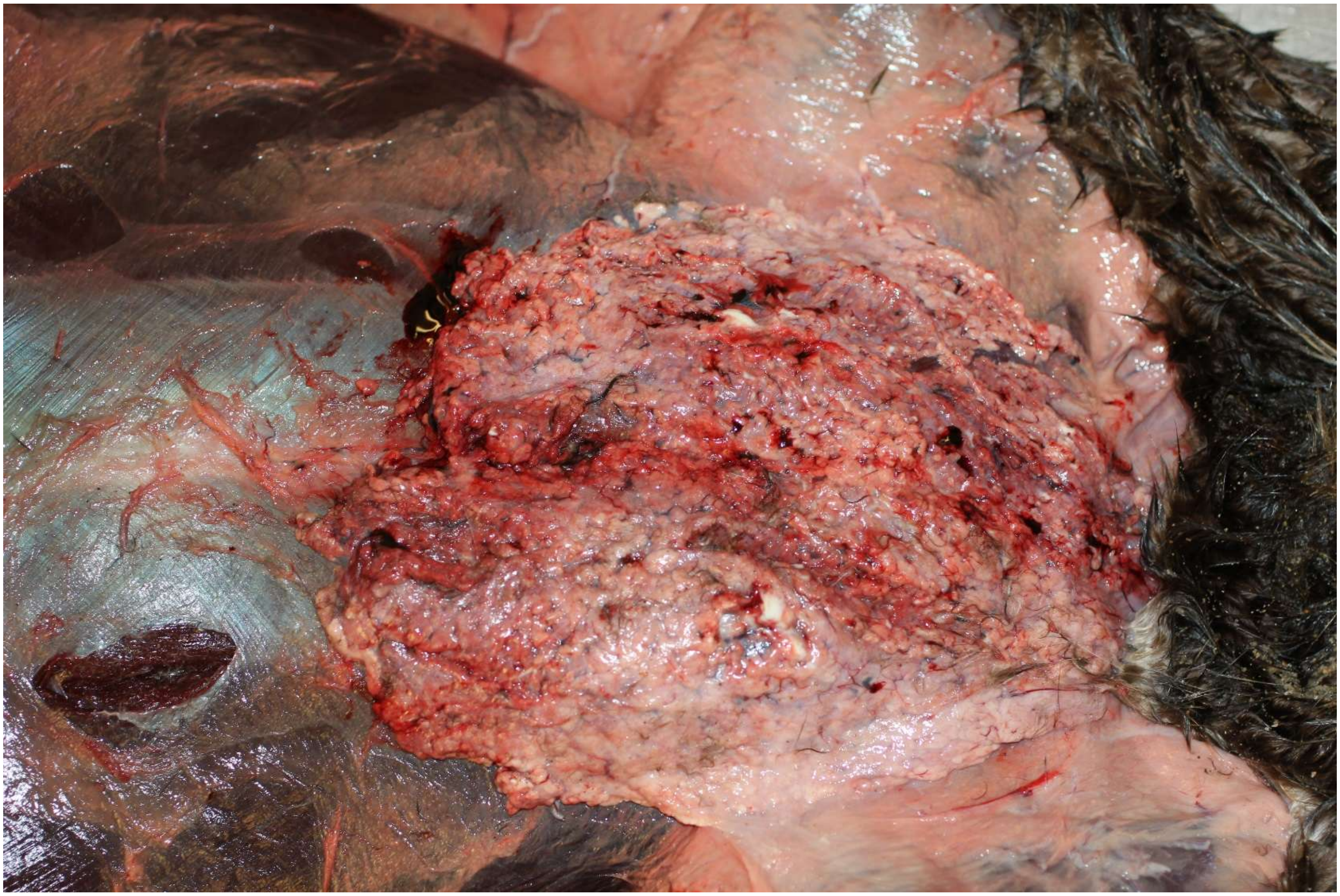


Top: Marked diffuse brain congestion Bottom: Putative hemorrhage in papillary muscle of left ventricle

Top: Reddish fluid around nose and mouth (edema) Bottom: Severe pulmonary edema, pleural effusion



Top: Mild cardiac mottling, very mild dilation   Bottom: Free-floating VHF, abdomen, hepatic congestion


Prominent mammary glands (Mid/late stage 3 female: first ½ of pup care)

STRANDED SEA OTTER FACT SHEET

SO# 8770-18

PERSON REQUESTING SO#: J. Fujii

DATE FOUND: 05 (DD) Mar (MMM) 2018 (YYYY)

MWVCRC# 18-0099

FOUND BY: PC RPC BO PM SBS SOB BIO UU Patty Brown

OTHER# BRD 1358-16

RECOVERY AREA: 12 **ATOS:** 341 **LAT / LONG (DD): N** 36.7267 **W** -121.8061 TC / GE

RECOVERY LOCATION: Salinas River National Wildlife Refuge (CITY / COUNTY; LOCATION DETAILS, LANDMARKS) **TAR ON BEACH:** N / Y / ?

COND: 1=ALIVE (EUTH: Y / N) 2=FRESH 3=MOD DECOMP 4=ADV DECOMP 5=MUMM/FRAG/SKEL 9=? **SCAVENGED:** 0=NO 1=SLIGHT 2=MOD 3=HEAVILY 9=?

SEX: F / M / ? **AGE:** 2=PUP 3=IM 4 or 14 =SA 5 or 15=AD 6=AGED AD 7=PUP OR IM 8=SA, AD, AA 9=?

TAGGED: N / Y / ? (Y=PG 2) **TAR ON OTTER:** N / Y / ? **OBV TRAUMA:** N / Y / ? **EST AGE:** 7-8 W / M / YR **BY:** CY, MM

TL: 129.5 CM **TAIL:** 29 CM **WT:** - KG **NOSE WOUND:** SIZE: N FRESHNESS: N

TEETH: 5=ALL MILK 6=SOME MILK 1=EXC 2=GOOD 3=FAIR 4=POOR 9=? REMARKS:

ECHINO: 0=NONE 1=SLIGHT 2=OBVIOUS 9=? (SKULL OR PCS EXAMINED, SEE BACK) REMARKS: Interesting echino pattern (skull saved)

GRIZZLE: 6=NATAL 7=JUV BUFF 1=NONE TO SLIGHT 2=TO EYES 3=TO LAMBDOIDAL CREST 4=TO CHEST 5=TO TAIL 9=?

RED ALGAE ON FUR: N / Y / ? VISUAL / UV LAMP 1=< 2% 2=2-10% 3=11-20% 4=>20% REMARKS:

NECROPSY: NO / F / G / D BY WHOM: B / BP / V / VP / P M. Miller, C. Young, K. Greenwald DATE: 06 Mar 2018

COND AT NEC: 2 / 3 / 4 / 5 **PREV FROZEN:** N / Y **LOCATION OF NECROPSY:** MWVCRC

SUBCU FAT: 0=NONE 1=SCANT 2=FAIR 3=MOD 4=ABUND 9=? **TARRY DIGESTA:** 0=NOT OBVIOUS 1=SLIGHT 2=OBVIOUS 9=?

FOOD IN GUT: 0=EMPTY 1=LITTLE 2=MED 3=FULL 9=? PREY:

ACANTH: UNK / NO / C / P / C=P / CP / PC INT: 0=NONE 1=MILD 2=MOD 3=HEAVY 9=? AB: 0=NONE 1=MILD 2=MOD 3=HEAVY 9=?

FETUS: N=NO Y=YES, NO SEX M=YES, MALE F=YES, FEMALE U=? TL: - CM CR: - CM WT: - GM

WOUNDS CHARC OF SHARK BITE: N / Y / ? **EFFORT TO CONFIRM:** 0=NONE 1=CURSORY 2=INTENSIVE 3= NA

WOUND DESCR: 1= NO OBVIOUS HEALING 2= INDICATION OF HEALING 3= INDICATION OF INFECTION 4= OBVIOUSLY OLD, HEALED 5= ? 6=NA

EVIDENCE WOUNDS ANTE-MORTEM: Y / ? / NA IF YES: SQ HEM OTHER: Healing

REMARKS:
From J. Fujii: Otter Name: Hagrid, N-1634-16-S, BRD 1358-16. Captured 6/2/2016 off Lover's Point as part of NSF research project. Given Radio (167.632) and TDR #1690058. Was 28.4 kg at capture. Generally seen offshore between Pt. Pinos and Del Monte Beach. Very little forage data, but mostly sandy prey (Fat innkeepers, crabs, clams, etc). Was last seen Feb 18, 2018 in Monterey Harbor. Looked emaciated and with potential fight wounds on flippers, tail, and nose.

Multiple full-thickness lacerations on flippers and tail with scant rounding of skin margins (scant healing). Lacerations on dorsal and ventral surface of phalanges with no visible scratches or tooth fragments. No other lacerations on body. Some lacerations rounded, others v-shaped, one long linear (~4cm). On opposite flipper skin was grooved and hair removed in linear to v-shaped pattern. No apparent nose or facial wounds. Trauma consistent with either VERY severe fight trauma or mild, focally extensive suspected shark bite (early subacute). Also thin to emaciated. TDR in falciform VHF in abdomen. All abdominal viscera and all pelvic muscle scavenged. PIT tag missing. Heart and lungs WNL (for advanced autolysis case). If trauma was caused by shark, the link to the COD is uncertain due to the location of the wounds and comparative mildness of the wounds.

PREMOLAR: N / UR UL LR LL **FUR:** N / Y **WHISKERS:** N / Y **OTHER SAMPLES:** N / Y (Y=SEE BACK) **PHOTOS:** N / Y

CAUSE OF STRANDING: 2 **IF CODE=10 OR 11, THEN PRIMARY:**

OTHER SIGNIFICANT FINDINGS:

DISPOSITION: CARCASS: 0 PELT: 0 SKELETON: 0 SKULL: 192 BACULUM: 0 PREMOLAR: 192

FACTSHEET2016_V1

CONTINUE ON BACK: N / Y

SO# 8770-18

TAG REF #: 1358-16 **KNOWN AGE:** ✔N / Y **IF YES:** KA<3 MO KA<6 MO KA< 12MO

TAGS: R: TQ / 3/4 / ____ (COL / POS / NO.) MISSING? ✔Y / N **L:** LG / 4/5 / ____ (COL / POS / NO.) MISSING? ✔Y / N **PIT:** 985141000930593 **WORKING:** Y / N / ✔?

TAG HX:
N-1634-16-S, BRD 1358-16. Captured 6/2/2016 off Lover's Point as part of NSF research project. Given Radio (167.632) and TDR #1690058. Was 28.4 kg at capture.

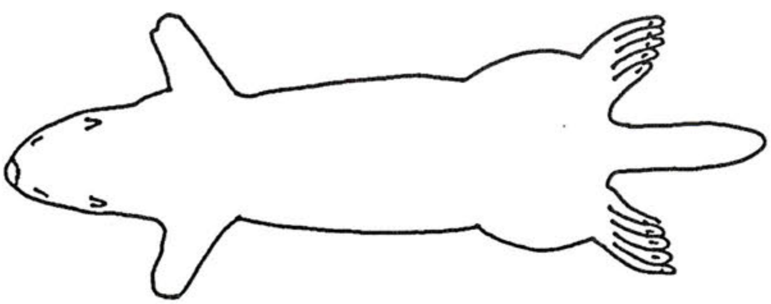
ECHINO: SKULL: ✔0=NONE 1=SLIGHT 2=OBVIOUS 9=? **PCS:** ✔0=NONE 1=SLIGHT 2=OBVIOUS 9=? REMARKS:

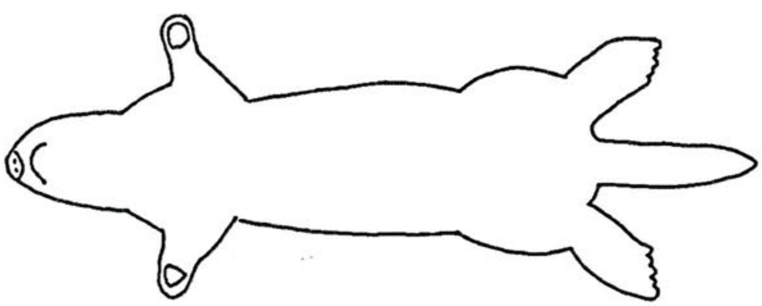
SAMPLES TAKEN: BI=BILE BL=BLOOD BR=BRAIN GC=GUT CONTENT HE=HEART KI=KIDNEY LI=LIVER LN=LYMPH NODE LU=LUNG MU=MUSCLE SP=SPLEEN UR = URINE ALL OTHER: NONE
FOR WHAT: WHOM:

HISTO SAMPLE: FULL / PARTIAL NONE

XRAY: 1=YES,GUNSHOT 2=YES,NOT GUNSHOT 3=YES,GUNSHOT:OLD HEALED WOUND

ADDITIONAL REMARKS:





CDFW SEA OTTER NECROPSY REPORT

California Department of Fish and Wildlife
Office of Spill Prevention and Response
Marine Wildlife Veterinary Care and Research Center
151 McAllister Way
Santa Cruz, CA 95060
(831) 469-1719

Sea Otter:	8776-18
UCD PATH:	18S0187
MWVCRC Necropsy:	18-0143
Report Date:	3/15/2018
Report Status:	Gross

CASE PROFILE

DFG/BRD#:	1133	**Report By:**	Miller
UON#:	N-1408-09-S	**Necropsy By:**	Miller, Dodd, Greenwald
MBA#:		**Necropsy Date:**	3/14/2018
Date Found:	3/8/2018	**Condition:**	Fresh
Condition Found:	Fresh	**Sex:**	Female
Live Strand:	No	**Age Class:**	Aged Adult
Euthanized:	No	**Estimated Age:**	10-12 MM
Date Died:		**Location:**	Floating off Monterey Bay Inn
Total Length (cm):	119	**County:**	Monterey
Weight (kg):	18.4	**ATOS:**	379
Nutritional State:	Emaciated	**DSOFS COD:**	11P
SQ Fat:	None	**Histopathology:**	Partial
Food in Gut:	None		

MORTALITY DATABASE CODING
Mortality Code 11p

Primary COD Cardiomyopathy
Sequela 1 Suspected coagulopathy/ DIC

Secondary COD Gastric ulcers/ melena

Tertiary COD Nephrosclerosis

Quaternary COD Marked tooth wear

5th: Emaciation (+/- prior ELS)

CASE BACKGROUND

Captured 8/24/09 off MBA, 17.9 kg, 116.6 cm TL, estimated age 8 yrs, no VHF, no TDR. 66 resights from Aug 2009 - 2010, no foraging data.

GROSS DIAGNOSES

Animal was partially frozen-thawed, and carcass held for a few days post-thaw because tag holes were not reported at the time of carcass collection. Tag holes found during preparations for a “gorpo session” at MWVCRC, and animal was set aside for pathologist examination.

1. Cardiomyopathy, subacute to chronic, moderate/marked, char. by moderate to marked myocardial pallor and streaking, esp. LVFW and atria

- Left and right heart failure, subacute to chronic, char. by hepatic passive congestion & hepatomegaly, & moderate pulmonary septal fibrosis & marked peritoneal, pleural, pericardial and subcutaneous effusion, bilateral pleuropulmonary venous shunts from ventral lungs to dorsal chest wall

1a. Suspected coagulopathy/ DIC characterized by mild fibrinous deposits at hepatic hilus & moderate/ severe acute hemoabdomen, multifocal SQ hemorrhage, moderate & cyanosis of pallor of gingiva, markedly pale heart and lungs, & scant blood in ventricles and atria (DDX acute hepatic thrombosis, but no definitive antemortem thrombi were found at gross necropsy)

2. Gastric ulcers and melena, moderate

3. Possible moderate bilateral nephrosclerosis secondary to cardiac disease & advanced age

4. Marked tooth wear

5. Late stage 5 female, likely early peri/post blastocyst-implantation pregnant in right uterine horn (but no fetus observed grossly)
   <u>-Emaciated (Doesn’t qualify as ELS at time of death due to presence of a large, well-developed CL, but may well have been ELS case that survived just beyond the ELS time frame</u>)
   -Medium white nose wound
   -Regressing mammary glands, no lactation, trace milk in left teat cistern (<100 ul)
   -Nipples very small and fully haired
   -Vulva mildly swollen, no bruising or matting
   -Est age MWVCRC 10-12 (estimate of ~18 yrs old based on age assessment on capture records seems a bit high based on necropsy findings from uterus & ovaries?)
   -Left ovary 1+ CA’s, no CLs, no paraovarian cysts, no follicles
   -Right ovary: Large 1.2 cm diameter yellow-pink LC, 2+ CAs, no follicles, no cysts
   -No apparent placental scars left, 2-3 right, right (pregnant) horn contained ~3ml tan cloudy fluid, but no grossly apparent fetus or fetal membranes

6. Emaciation, severe (+/- prior ELS?) (Secondary to 1-5, pres.)

7. Perimortem seawater aspiration pres. (recovered from water)
   -Copious red-stained fluid & froth in/around moth, nose, trachea & bronchi (sec. to #1 & #7, pres.)

<u>INCIDENTAL</u>

Marked bilateral adrenocortical nodular hyperplasia (Geriatric otter)

Focal renal cortical cyst, right kidney

GROSS SUMMARY

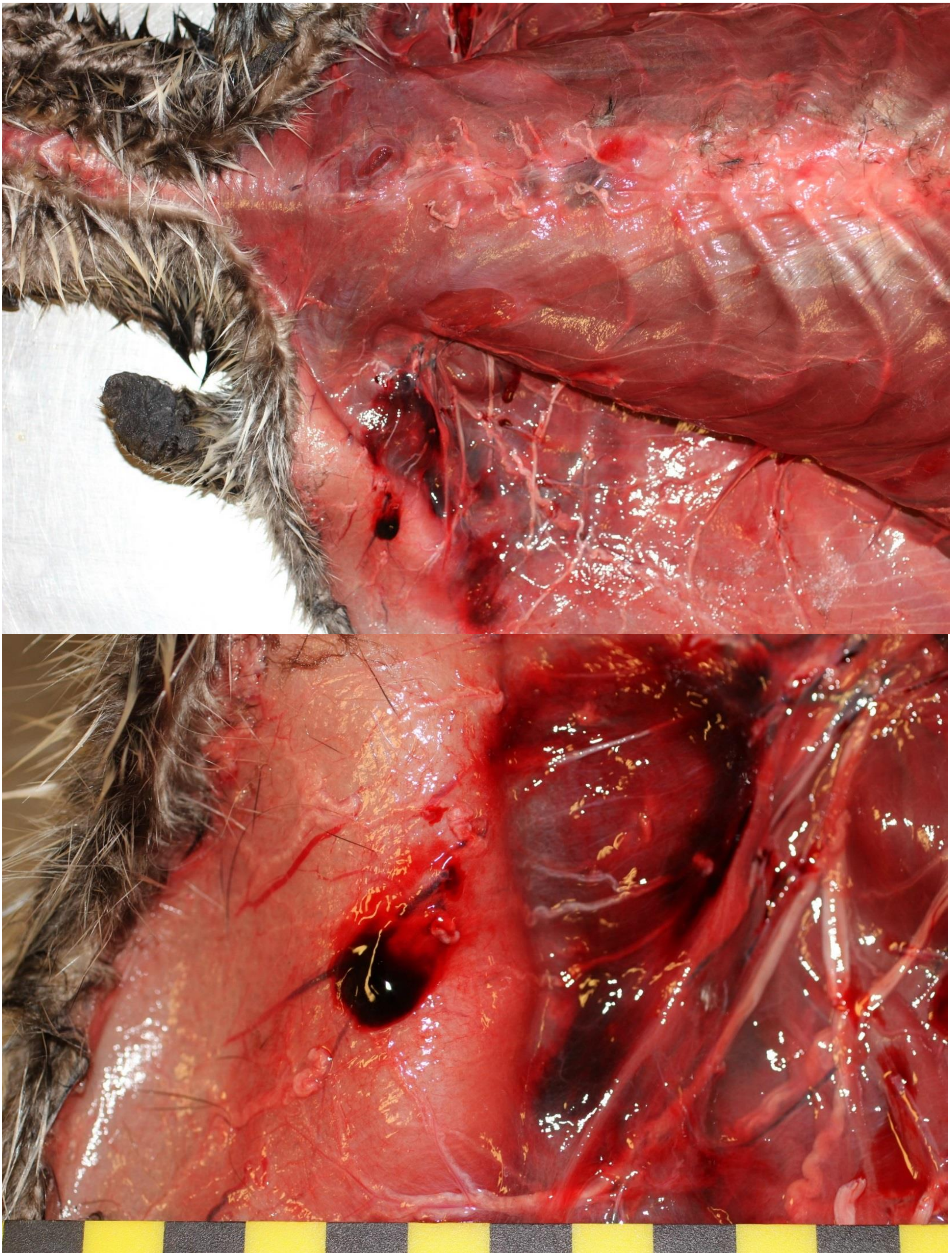
Pending histopathology, the putative cause of death is moderate to severe cardiomyopathy resulting in left and right heart failure, and suspected perimortem coagulopathy secondary to severe cardiovascular disease +/- nephrosclerosis.

Histopathology may help confirm whether the cardiomyopathy was a result of domoic acid intoxication &/or protozoal disease. Pending case review, DA is considered more likely due to prominent ventricular streaking that is suggestive of prior cardiotoxicity.

This animal’s reproductive tract looked younger than 18 years at necropsy-The estimated age at necropsy was closer to 10-12 years. It would be interesting to see what age assessment via tooth examination yields.

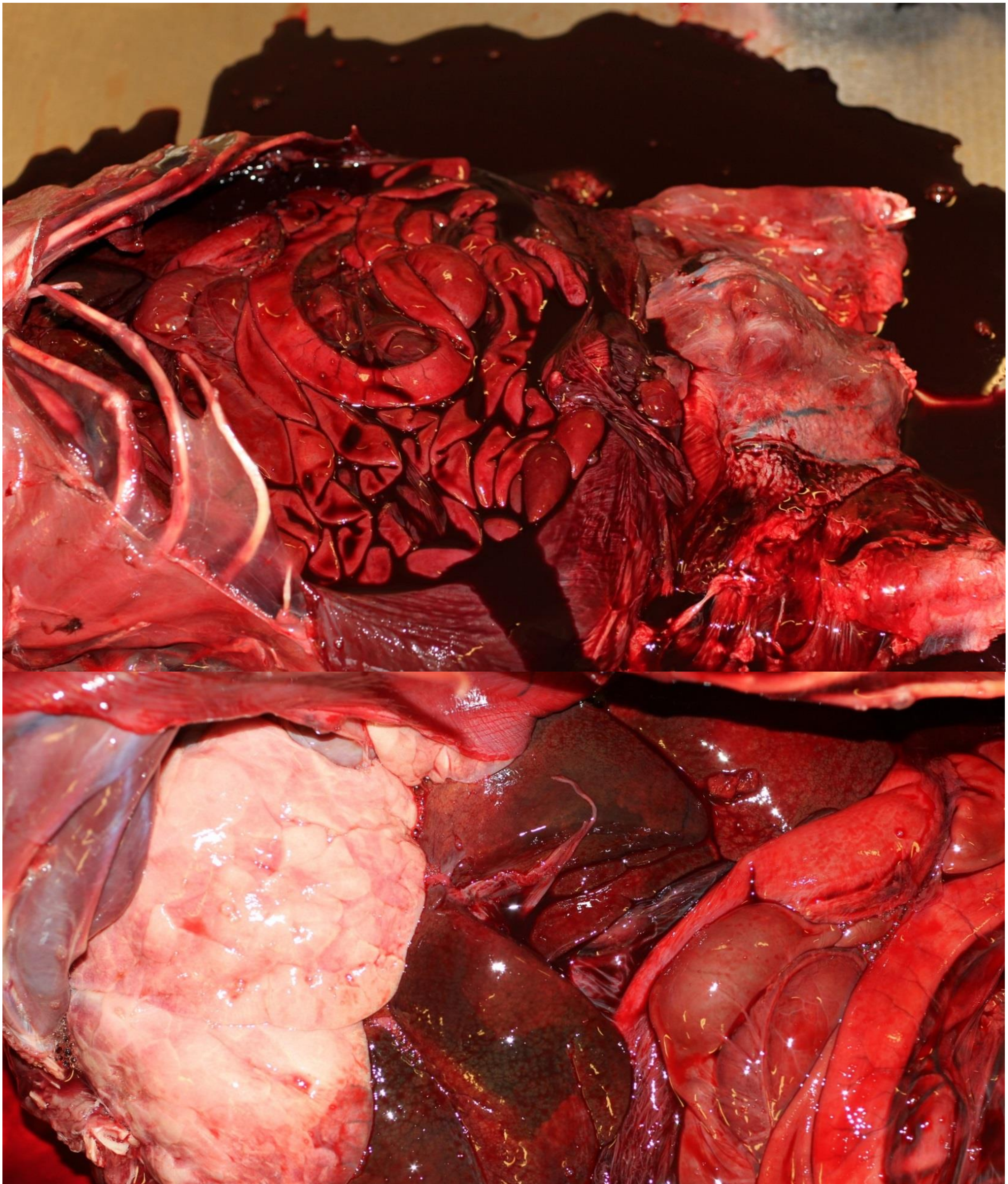
Saved:
Gross photos
Partial histopath: Liver, heart, kidney, lung, tongue,
Frozen: Liver, urine, pericardial fluid, pelage
Room temp: Hair, whisker, tooth

Medium white nose wound & copious red-tinged fluid around nose and mouth

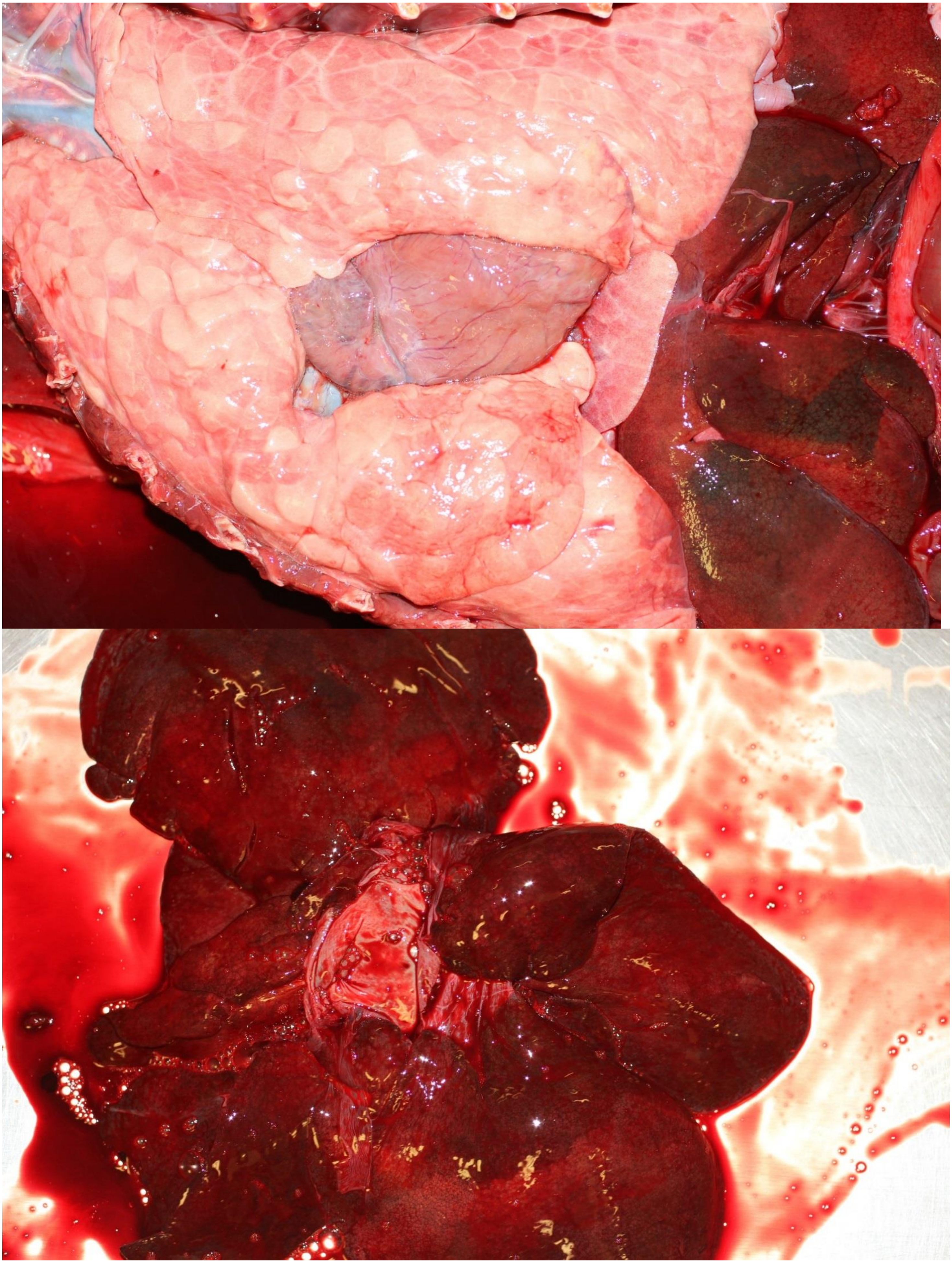


Multifocal acute subcutaneous hemorrhage, right axilla and antebrachium

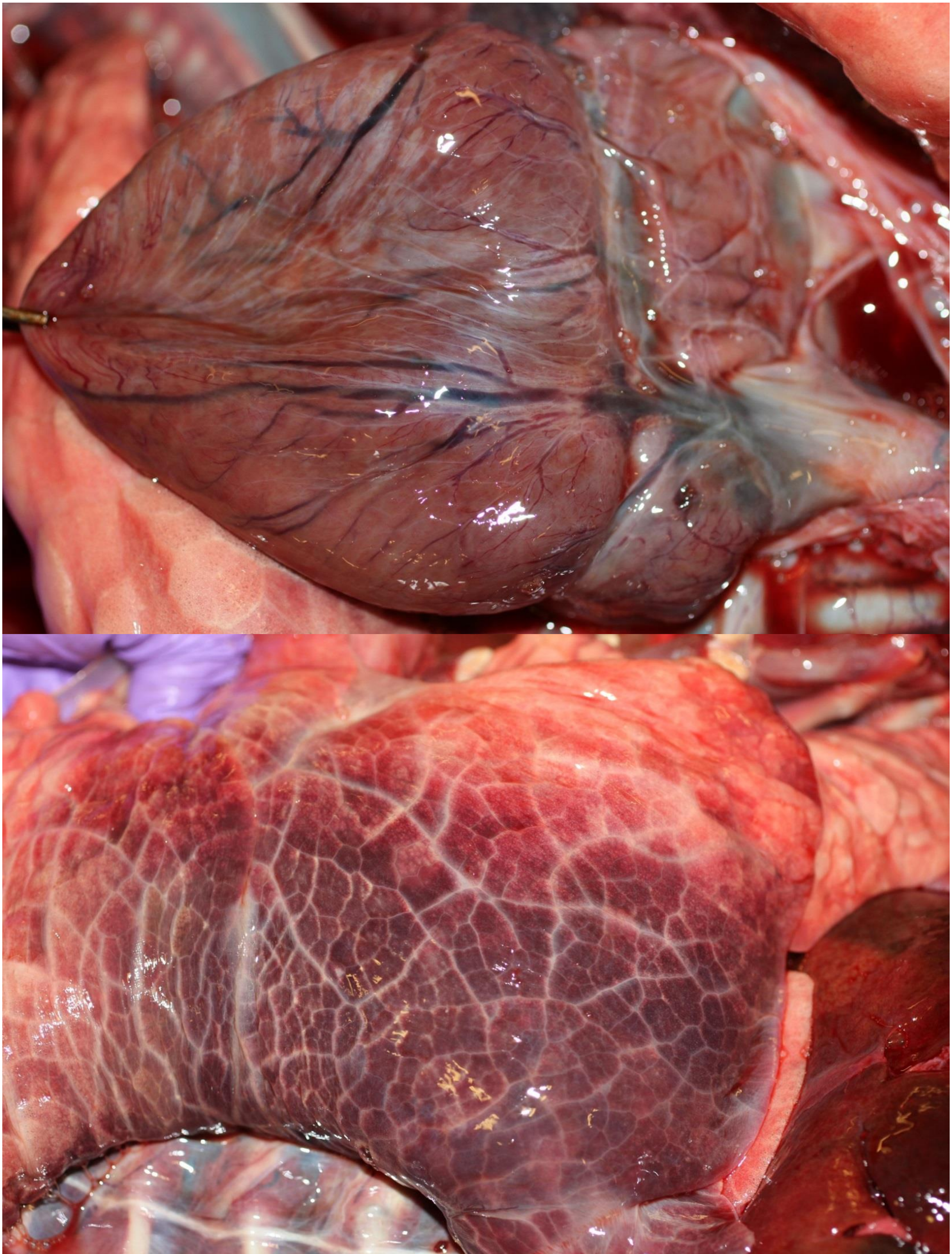
Multifocal acute subcutaneous hemorrhage, left axilla and antebrachium
Combination of severe peritoneal effusion & hemoabdomen secondary to cardiomyopathy, pres.



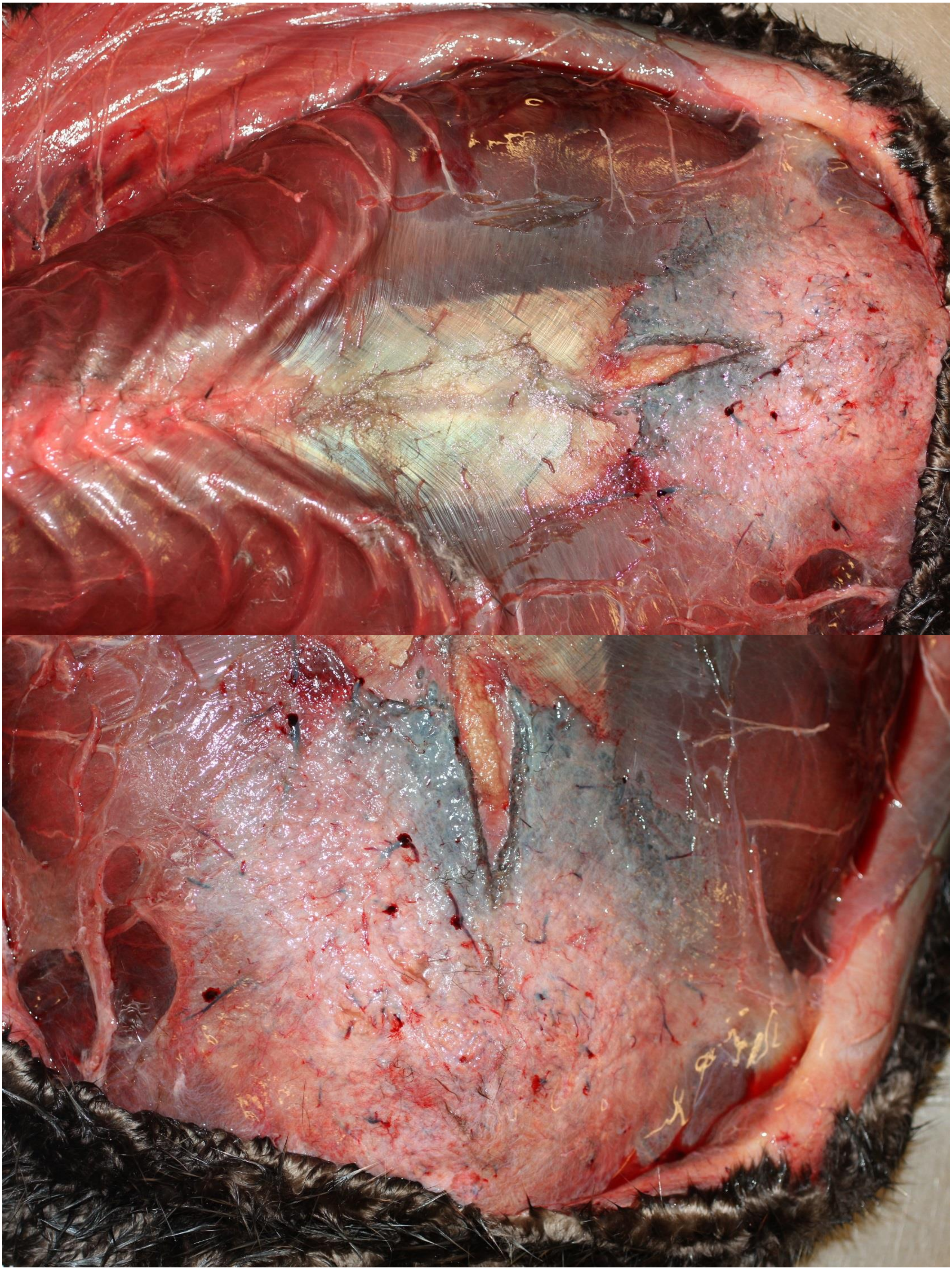
Combination of severe peritoneal effusion & hemoabdomen secondary to cardiomyopathy, pres.
Moderate hepatic passive congestion & hepatomegaly, & diffusely pale, hypoperfused lungs



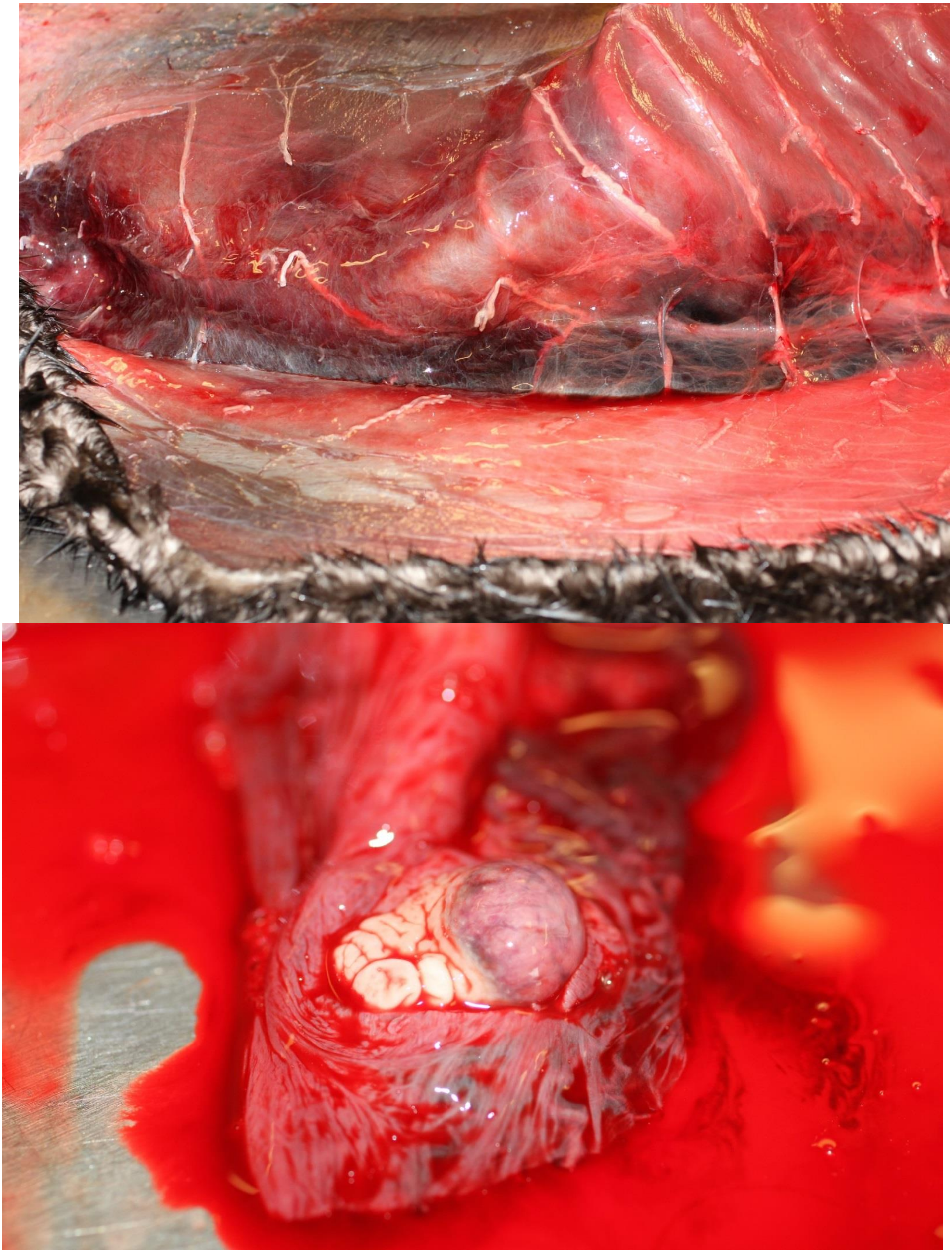
Moderate hepatic passive congestion & hepatomegaly (SA/ chronic right heart failure),
& diffusely pale, severely hypoperfused heart & lungs



Severe myocardial damage (esp. left ventricle and atria) associated with cardiomyopathy
Diffuse moderate pulmonary septal fibrosis (SA/ chronic left heart failure)



Fluid-distended abdomen and regressing mammary glands with no apparent lactation



Top: Possible antemortem SQ effusion (+/- postmortem leakage from abdomen & chest)
Bottom: Large corpus luteum on right ovary (animal was likely post-implantation pregnant, but a fetus was not observed grossly-possibly was still a blastocyst & was too small to see)

CDFW SEA OTTER NECROPSY REPORT

California Department of Fish and Wildlife
Office of Spill Prevention and Response
Marine Wildlife Veterinary Care and Research Center
151 McAllister Way
Santa Cruz, CA 95060
(831) 469-1719

Sea Otter:	8962-18
UCD PATH:	18S0481
MWVCRC Necropsy	18-0262
Report Date:	7/6/18
Report Status:	Gross

CASE PROFILE

DFG/BRD#:	1268	**Report By:**	**M. Miller**
UON#:	N-1546-13-S	**Necropsy By:**	Miller, Batac, Greenwald, Dodd
MBA#:		**Necropsy Date:**	7/6/2018
Date Found:	7/4/2018	**Condition:**	Adv Decomp
Condition Found:	Adv Decomp	**Sex:**	Male
Live Strand:	No	**Age Class:**	Aged Adult
Euthanized:	No	**Estimated Age:**	11-13 years MM
Date Died:		**Location:**	Hollister Ranch,200m E of San Augustine Ramp
Total Length (cm):	133.5	**County:**	Santa Barbara
Weight (kg):		**ATOS:**	1136
Nutritional State:	Excellent	**DSOFS COD:**	3
SQ Fat:	Abundant	**Histopathology:**	Partial
Food in Gut:	Unknown		

MORTALITY DATABASE CODING
Mortality Code 3 (uncertain w/o trauma)
Primary COD Acute DA intoxication possible
Sequela 1 Multi-organ congestion?
Secondary COD Mod/ marked tooth wear
Tertiary COD None
Quaternary COD None

CASE BACKGROUND

Adult male sea otter captured, tagged and implanted with both a TDR and a VHF transmitter on 11 March 2013 at San Augustine in Santa Barbara County. Estimated 7 years of age by M Staedler.

04 July 2018: Sue Benech collected advanced decomposed tagged sea otter and put on ice. 05 July 2018: Brian Hatfield transported from Hollister Ranch and it was put on scheduled TMMC transport to Moss Landing.

GROSS DIAGNOSES

ADVANCED DECOMPOSITION & MARKED POSTMORTEM SCAVENGING

1.) Uncertain with no trauma: Acutely dead AA M sea otter with no gross evidence of trauma, and abundant SQ, peri-renal and coronary groove adipose (PHOTO) (Based on the stranding period, stranding location & gross presentation, probable DDX include acute domoic acid intoxication +/- systemic *S. neurona*-Limited HP pending)

    -Right kidney & (probable) liver: Moderate diffuse congestion

2.) Aged adult male (Est 11-13) with grizzling at least to chest, and mod/ marked tooth wear, especially caudal molars, but no tooth fractures or grossly infected teeth. Missing central incisors may be a PM artifact (PHOTO)

    -Age was estimated at 7 during capture 3/11/13

<u>INCIDENTAL FINDINGS</u>

1.) No VHF, TDR or PIT tags in carcass (Marked postmortem scavenging through anus with hind limb & pelvic muscles, testicles, spleen, left kidney, omentum, and most of stomach and intestines scavenged postmortem. Tongue, larynx and soft palate and much of cranial skeletal muscle scavenged through mouth)

2.) Ventral midline surgical scar healed and unremarkable

3.) RR flipper: Two flipper tags and additional small round hole in interdigital web flipper hole
LR flipper: One flipper tag and possible healed flipper tag hole left? (R/O captured and tagged >1 time?-Please see capture records & DSOFS for details)

    -Extra hole on RR flipper was noted during 3/11/13 capture-No clear evidence of prior tagging HX

4.) Likely died in the water:

    -No apparent postmortem myiasis (maggots), and extensively sloughed pelage

5.) All visible lymph nodes WNL

6.) No gross evidence of bacterial sepsis, peritonitis, pyothorax, fungal infection or cardiac vavular endocardiosis or endocarditis

GROSS SUMMARY

This tagged AA M southern sea otter appears to have died acutely with abundant SQ, peri-renal and coronary groove adipose. There is no gross evidence of trauma, or fungal or bacterial infection. All visible lymph nodes are WNL.

There is severe, diffuse autolysis, and marked postmortem scavenging of the abdomen, pelvis and rostral head. No instrumentation (VHF or TDR) was present in the abdomen at gross necropsy, and all skeletal muscle had been scavenged from the hind limbs and peri-pelvic muscle, so PIT scanning was not possible. Lack of visible maggot presence is suggestive of death in the water, with the carcass stranding later during decomposition.

The remaining right kidney is diffusely congested, and the liver may also be congested (hard to be sure due to advanced autolysis). Given the overall case presentation, stranding location and stranding period, acute domoic acid intoxication is suspected. However, it is not possible to confirm this diagnosis due to advanced autolysis and absence of optimal samples for DA testing.

Given this animal's older age, a less likely differential is systemic sarcocystosis. The freshest three pieces of skeletal muscle available (diaphragm, masseter and temporal muscle) will be examined via histopathology for the presence of protozoal sarcocysts.

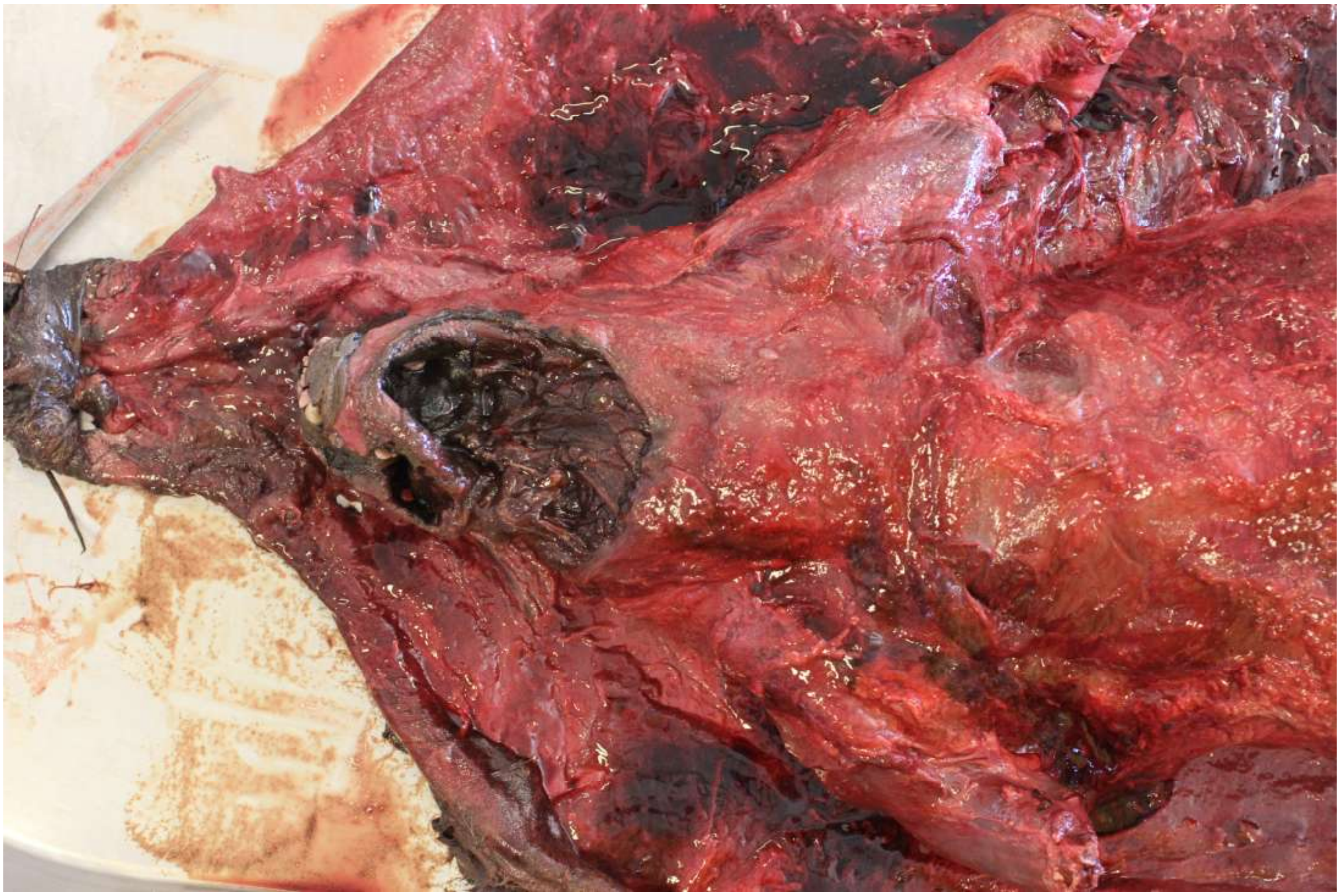
SAVED:

1.) UL premolar
2.) Hair (no whiskers present)
3.) Frozen skeletal MM (for genetics, if desired)
4.) FF masseter & temporal MM, diaphragm for HP (attempt to R/O systemic sarcocystosis)

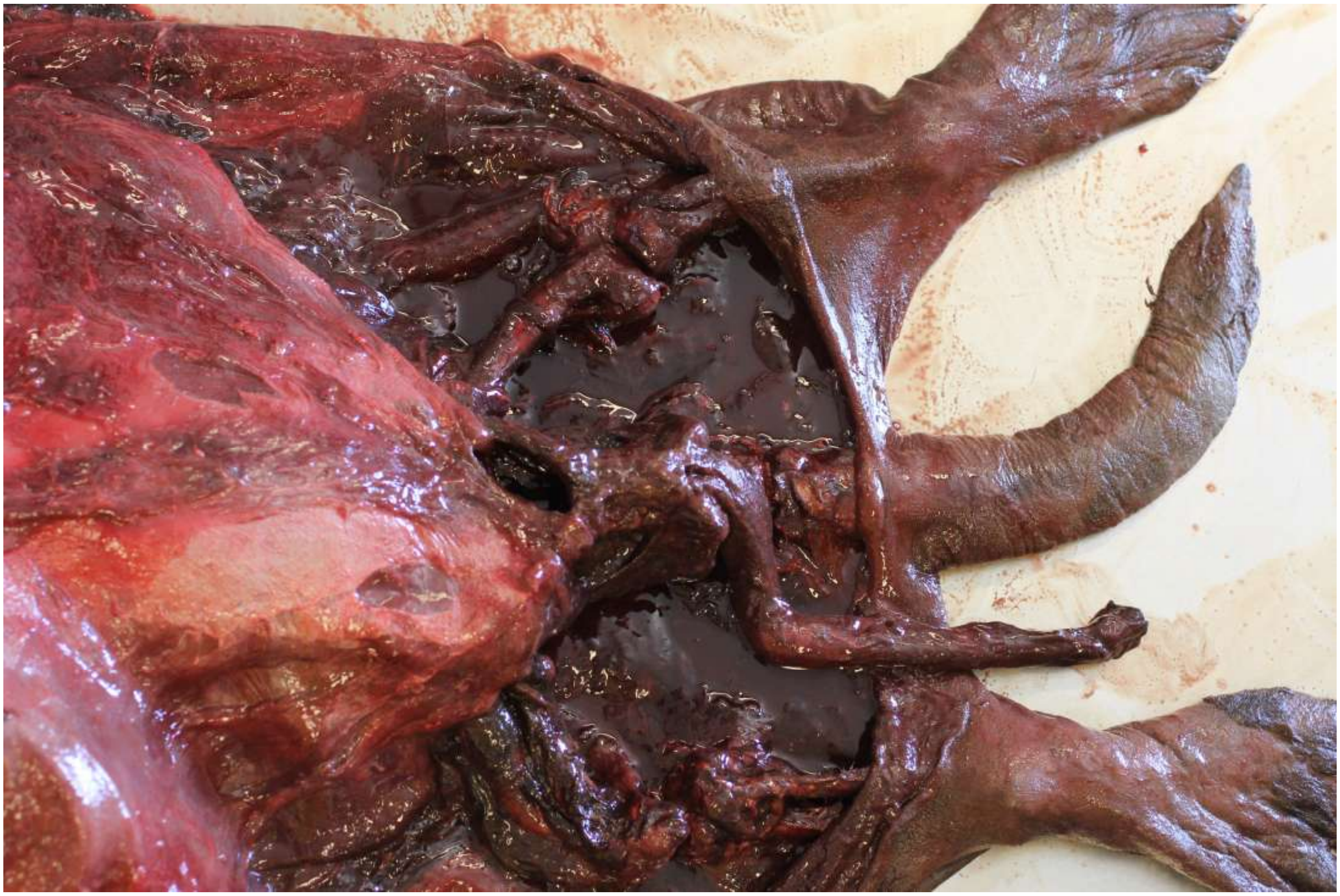
PENDING:

1.) Muscle HP

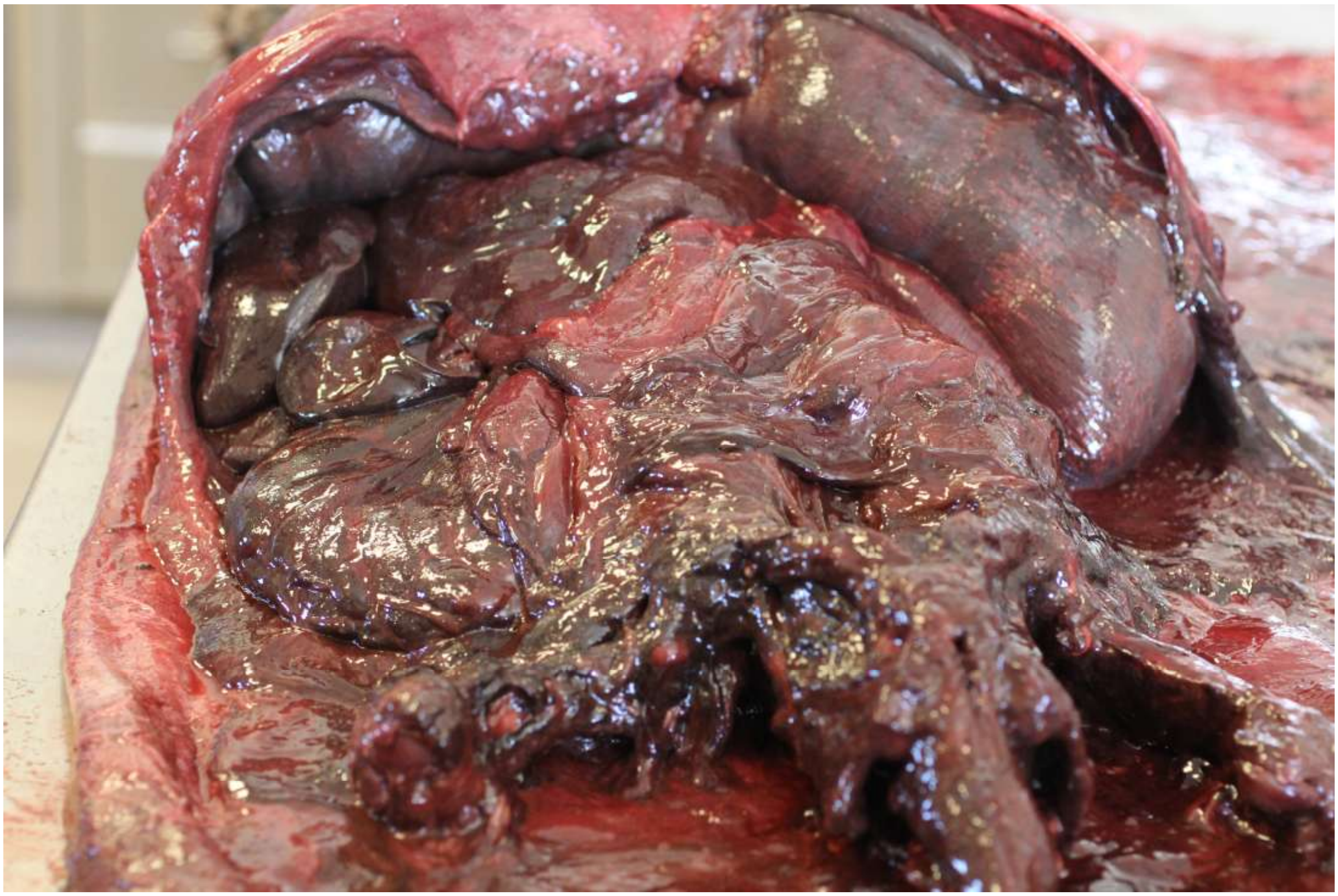
CARCASS ON THE BEACH AT TIME OF RECOVERY



PM SCAVENGING, HEAD



PM SCAVENGING: HIND LIMBS, PELVIS & ABDOMEN



PM SCAVENGING: ABDOMEN (VIEW FROM VENTRAL TAIL)
(DIAPHRAGM IS ARTIFACTUALLY INFLATED WITH GAS FROM DECOMPOSITION)

STRANDED SEA OTTER FACT SHEET SO# 9004-18

PERSON REQUESTING SO#: HARRIS

DATE FOUND: 31 (DD) JUL (MMM) 2018 (YYYY)

MWVCRC# ~~18-0347~~ 18-0362

FOUND BY: PC RPC BO PM SBS SOB BIO UU PSLHP

OTHER# BRD 1229-12, 40N N-1507-12-S

RECOVERY AREA: 36 ATOS: 894 LAT / LONG (DD): N 35.1686 W 120.7537 TC / GE

RECOVERY LOCATION: Port San Luis, SLO Co (CITY / COUNTY), Floating East side Hardford Pier (LOCATION DETAILS, LANDMARKS) TAR ON BEACH: N / Y / ?

COND: 1=ALIVE (EUTH: Y / N) 2= FRESH 3=MOD DECOMP 4=ADV DECOMP 5=MUMM/FRAG/SKEL 9=? SCAVENGED: 0=NO 1= SLIGHT 2=MOD 3=HEAVILY 9=?

SEX: F M / ? AGE: 2=PUP 3=IM 4 or 14 =SA 5 or 15 =AD 6=AGED AD 7=PUP OR IM 8=SA, AD, AA 9=?

TAGGED: N / Y / ? (Y=PG 2) TAR ON OTTER: N / Y / ? OBV TRAUMA: N / Y / ? EST AGE: 6-7 W / M / YR BY: C Young

TL: — CM TAIL: 27 15th CM WT: — KG NOSE WOUND: SIZE: D FRESHNESS: D

TEETH: 5=ALL MILK 6=SOME MILK 1=EXC 2=GOOD 3=FAIR 4=POOR 9=? REMARKS:

ECHINO: 0=NONE 1=SLIGHT 2=OBVIOUS 9=? (SKULL OR PCS EXAMINED, SEE BACK) REMARKS:

GRIZZLE: 6=NATAL 7=JUV BUFF 1=NONE TO SLIGHT 2=TO EYES 3=TO LAMBDOIDAL CREST 4=TO CHEST 5=TO TAIL 9=?

RED ALGAE ON FUR: N / Y / ? VISUAL / UV LAMP 1=< 2% 2=2-10% 3=11-20% 4=>20% REMARKS:

NECROPSY: NO / F / G / D BY WHOM: B / BP / V / VP / P F Batac, C Young DATE: 09 Aug 2018

COND AT NEC: 2 / 3 / 4 / 5 PREV FROZEN: N / Y LOCATION OF NECROPSY: MWVCRC

SUBCU FAT: 0=NONE 1=SCANT 2=FAIR 3=MOD 4=ABUND 9=? *some present but can't assess amt. TARRY DIGESTA: 0=NOT OBVIOUS 1=SLIGHT 2=OBVIOUS 9=?

FOOD IN GUT: 0=EMPTY 1=LITTLE 2=MED 3=FULL 9=? PREY: hard shell parts (clam?)

ACANTH: UNK / NO / C / P / C=P / CP / PC INT: 0=NONE 1=MILD 2=MOD 3=HEAVY 9=? AB: 0=NONE 1=MILD 2=MOD 3=HEAVY 9=?

FETUS: N=NO Y=YES, NO SEX M=YES, MALE F=YES, FEMALE U=? TL: — CM CR: — CM WT: — GM

WOUNDS CHARC OF SHARK BITE: N / Y / ? EFFORT TO CONFIRM: 0=NONE 1=CURSORY 2=INTENSIVE 3= NA

WOUND DESCR: 1= NO OBVIOUS HEALING 2= INDICATION OF HEALING 3= INDICATION OF INFECTION 4= OBVIOUSLY OLD, HEALED 5= ? 6=NA

EVIDENCE WOUNDS ANTE-MORTEM: Y / ? NA IF YES: SQ HEM OTHER:

REMARKS:

Tag hole (R 1/2) found and VHF palpated at necropsy No PIT tag detected

↳ PIT tag found, was no detected by scanner

Surgical scar unremarkable

VHF free-floating (164.955)

TDR ~~entrap~~ wrapped in omentum #1290722) but not entrapped

Regressing mammary tissue

PREMOLAR: N / UR UL LR LL ~~missing~~ / already taken FUR: N / Y WHISKERS: N / Y OTHER SAMPLES: N / Y (Y=SEE BACK) PHOTOS: N / Y

CAUSE OF STRANDING: 1 (unknown) IF CODE=10 OR 11, THEN PRIMARY:

OTHER SIGNIFICANT FINDINGS:

DISPOSITION: CARCASS: 80 PELT: Ø SKELETON: Ø SKULL: ~~Ø~~ 192 BACULUM: Ø PREMOLAR: ~~Ø~~ 192

FACTSHEET2016_V1

FROZEN

TO MWVCRC 2 AUG

↳ CAS15

CONTINUE ON BACK: N / Y

JH 8/15/18

R LG 1/2, L TQ 1/2
BRD 1229-12
UON N-1507-12-S
PIT SLO 2012025
Captured 05 OCT, 2012, PT BUCHON

- Last pregnancy on R horn (placental band present)
- No gastric erosions
- Fat on kidneys/heart
- No sand in trachea
- Heart valves look normal

- X-rays not taken

CDFW SEA OTTER NECROPSY REPORT

California Department of Fish and Wildlife
Office of Spill Prevention and Response
Marine Wildlife Veterinary Care and Research Center
151 McAllister Way
Santa Cruz, CA 95060
(831) 469-1719

Sea Otter:	9018-18
UCD PATH:	18s0587
MWVCRC Necropsy	18-0410
Report Date:	8/13/2018
Report Status:	Gross

CASE PROFILE

DFG/BRD#:	1375	**Report By:**	**Miller**
UON#:	N-1651-17-S	**Necropsy By:**	Miller, Dodd, Batac, Young
MBA#:		**Necropsy Date:**	8/13/2018
Date Found:	8/10/2018	**Condition:**	Mod Decomp
Condition Found:	Mod Decom	**Sex:**	Female
Live Strand:	No	**Age Class:**	Adult
Euthanized:	No	**Estimated Age:**	7-9 by M. Miller
Date Died:		**Location:**	Seaside Beach
Total Length (cm):	119	**County:**	Monterey
Weight (kg):		**ATOS:**	366
Nutritional State:	Emaciated	**DSOFS COD:**	11P
SQ Fat:	Scant	**Histopathology:**	Full
Food in Gut:	Unknown		

MORTALITY DATABASE CODING

Primary COD Possible DA intoxication

Sequela 1 Possible perimortem seawater aspiration

Secondary COD Possible ELS

Tertiary COD Gastric erosions and melena

Quaternary COD Marked tooth wear

CASE BACKGROUND

Captured at Otter Point on 9/27/17, 18.8 kg, 115.5 cm, estimated at 10 or 11 years old by Marissa Young, and not palpably pregnant.

NSF study animal captured 27 Sept. 2017. Was last heard 7 Aug 2018 at Point Pinos. Last seen 30 July 2018 at Otter Point with large pup (25.4 weeks). Had been seen resting with constant tremor on right hind limb since 20 May 2018. Has VHF transmitter, but no TDR. Diet predominantly mussels and urchins.

Per Jessica Fujii

GROSS DIAGNOSES

Moderately decomposed

1. Possible domoic acid intoxication (Pending histopathology)

-Hx chronic right hind limb tremor
-Moderate to marked vascular congestion of meninges, and possible moderate diffuse brain swelling
-Abundant reddish fluid around nose and mouth

1a. Possible perimortem seawater aspiration:
-Lungs dark red-black and wet (scant septal edema)
-Serous pleural effusion (est. approx. 150 ml)
-Approx. 7 ml of red-tinged pericardial fluid

2. Possible ELS (Pending histopathology)

-Estimated as adult female at necropsy (7-9 years) (Assessed as aged adult during captures 1 year previously)
-Was observed alive with large pup (25.4 weeks) 14 days prior to carcass recovery as a moderate decomp
-Thin animal with moderate symmetrical muscle atrophy and scant SQ adipose, but moderate omental and mild peri-renal adipose. No coronary adipose (animal seems a bit “out of cycle for a classical ELS case: Review HP and repro staging, and R/O forced copulation of animal with CNS Dz if possible)
-Reproductive stage 5 (pending HP)
-Moderate (~4-5 mm thick) pink mammary tissue and large nipples, not lactating
-Large pink/red nose wound
-Ovaries: 2+ CAs, 2+ follicles or early CLs (pending HP), no paraovarian cysts
-Uterine horns small and symmetrical (partially scavenged)
-Vulva not apparent due to PM scavenging

3. Gastric erosions, body and pylorus and melena

4. Marked tooth wear

5. Marked diffuse bilateral adrenal cortical hypertrophy

INCIDENTAL FINDINGS:

1. VHF transmitter possibly free-floating (abdomen partially scavenged), no TDR

2. Small fibrous adhesion/fibrous band running from hepatic quadrate lobe to ventral aspect of ventral midline abdominal incision. Sx incision otherwise unremarkable

3. Abdomen, pelvis and both eyes scavenged postmortem: Missing both eyes, bladder, part of uterus, spleen and omentum, and most of intestines)(except duodenum). VHF transmitter lodged inside of pelvis at necropsy

4. Intestinal Corynosoma (parasite load unknown due to PM scavenging of most of intestines)

GROSS SUMMARY

Findings from gross necropsy were not definitive, so further assessment will be performed via histopathology. Possible differentials for the cause of death include DA intoxication and ELS. Mating-associated drowning is a less likely possibility.

Saved:

Most tissues saved for HP (except eyes, intestine, bladder, mammary tissue)
Frozen: Pericardial fluid, whole blood, brain, lung, liver, kidney, spleen, stomach, bile, lymph nodes, tongue, heart muscle,
Caudal limbs and pelvic bones saved for comparison with bones from boat strike cases

CDFW SEA OTTER NECROPSY FINAL REPORT

California Department of Fish and Wildlife
Office of Spill Prevention and Response
Marine Wildlife Veterinary Care and Research Center
151 McAllister Way
Santa Cruz, CA 95060
(831) 469-1719

Sea Otter:	9071-18
UCD PATH:	18S0769
MWVCRC Necropsy	18-0463
Report Date:	11/19/2018
Report Status:	Final

CASE PROFILE

DFG/BRD#:	1361	**Report By:**	C. Young, F. Batac, M. Miller
UON#:	N-1637-16-S	**Necropsy By:**	F. Batac, C. Young, K. Greenwald, E. Dodd
MBA#:		**Necropsy Date:**	10/5/2018
Date Found:	10/4/2018	**Condition:**	Adv Decomp
Condition Found:	Mod Decom	**Sex:**	Female
Live Strand:	No	**Age Class:**	Adult
Euthanized:	No	**Estimated Age:**	6
Date Died:		**Location:**	Stillwater Cove (recovered from water)
Total Length (cm):	115	**County:**	Monterey
Weight (kg):	23.5	**ATOS:**	421
Nutritional State:	Good	**DSOFS COD:**	9
SQ Fat:	Moderate	**Histopathology:**	Partial
Food in Gut:	Full		

MORTALITY DATABASE CODING

Primary COD: Research-related death

Sequela 1: Severe omental “boloing” (torsion)

Sequela 2: Omental infarction and intestinal entrapment

Sequela 3: Serofibrinous peritonitis and effusion

Sequela 4: Possible sepsis

Secondary COD: Cardiomyopathy/DCM, mild/mod

Tertiary COD: None

Quaternary COD: None

CASE BACKGROUND

Captured once on 6/2/2016 at Otter Point, 14.4 kg, 110 cm, TDR 1690069, VHF 167.792, PIT 985141000930644.

M. Staedler 04Oct2018:

Sea Otter “Colleen” BRD # 1361-16; UON N-1636-16-S

Last visual was on 9/26 with a 13.71 week old pup. Two radio re-sights were done after that date, one on 9/27 and the other on 9/29. She is usually seen at Carmel Beach, Stillwater Cove area or Pescadero Point. Diet consists of mussels, crabs, snails.

This was her second pup that we know of, her previous one being in 2016 which did not survive; she lost it after a month. We estimated her to be fairly young at captures; 3 years of age

On another note, she was captured at Otter Point, in the summer, but left the area to “head south” in the fall, returning briefly for a few re-sights in November in Otter Point, back south, only to return to Otter Point in May/June of 2017 where she continued to go back and forth between these two general areas

FINAL DIAGNOSES

Advanced decomposition at necropsy

1) Post-surgical TDR extrusion from falciform ligament, with subsequent fibrous omental-falciform adhesion, and omental entrapment of both TDR and VHF transmitter inside omental bursa (PHOTO)
- Omentum was attached to the falciform ligament cranial to the surgical incision (Post-surgical adhesion secondary to TDR extrusion into abdomen, pres.) (PHOTO)
- Ventral midline surgical incision grossly unremarkable with no apparent adhesions

1a.) Severe omental “boloing” (torsion) secondary to both TDR and VHF entrapment inside omental bursa, forming two separate, tightly intertwined “bolos” (PHOTO)
- Omental stalk associated with VHF entrapment very tightly twisted, with three 360 full turns (1,080 degree omental torsion) (PHOTO)
- Omental torsion associated with TDR entrapment located further down the resulting omental stalk and more loosely twisted than the VHF

1b.) Severe omental infarction (gross diagnosis), and severe multifocal intestinal entrapment and impaction by torsed omentum, with marked venous engorgement of effected mesenteric blood vessels, and marked peri-intestinal perivascular mesenteric edema, char by:

- Omentum associated with areas of instrument entrapment and twisting is brownish-red and markedly friable (PHOTO)
- TDR, VHF, omentum, and intestinal loops tightly entangled at multiple locations (PHOTO)
- Tightly twisted omental stalk wrapped around small and large intestine in at least two locations, with secondary severe serosal pallor, luminal constriction, and segmental proximal intestinal impaction of ingested prey (purple urchin, snail, mussel, crab)
- Mesentery adjacent to areas of intestinal constriction/impaction dark reddish-black (venous congestion), with focally severe segmental perivascular edema (PHOTOS)

1c.) Marked serofibrinous omentitis, peritonitis and effusion (PHOTO)

- Marked serofibrinous peritoneal effusion with abdominal dilation and prominent fluid wave (PHOTO)
- Peritoneum and mesentery: Multifocal fibrin tags +/- possible fibroplasia (PHOTO)
- Moderate to marked mesenteric lymphadenopathy (PHOTO)
- No intestinal acanthocephalans, and no grossly visible peritoneal acanthocephalans
- No microscopic evidence of prior/resolving acanthocephalan peritonitis

1d.) Possible perimortem bacterial sepsis, char. by:

- Moderately enlarged spleen

2) Mild/moderate cardiomyopathy (and suspect DCM), char. by:

- Mild/moderate diffuse myocardial pallor (PHOTO)
- Moderate/marked bilateral cardiac dilation with prominent double apex (PHOTO)
- Mild/moderate myofiber loss and stromal fibrosis (most severe in LVFW, IVS, apex & left ventricular papillary muscle)
- No clear evidence of congestive heart failure on histopathology, but advanced autolysis precluded precise assessment

INCIDENTAL FINDINGS:

1) Prominent perivulvar tangles (Possible forced perimortem out-of-cycle copulation of non-estrus female secondary to severe illness) (PHOTO)

- Reproductive stage: Early stage 4 (mid pup care period, pres.), char. by:
- Abundant thick, dark pink mammary tissue with slight lactation (PHOTO)
- Left ovary: 1 CA, 1 paraovarian cyst
- Right ovary: 1-2 CAs
- Uterine horns symmetrical, placental bands left and right, most recent pregnancy on left horn
- Nose wound: Unknown due to postmortem decomposition (PHOTO)
- Moderate nutritional condition, char. by moderate SQ and coronary adipose

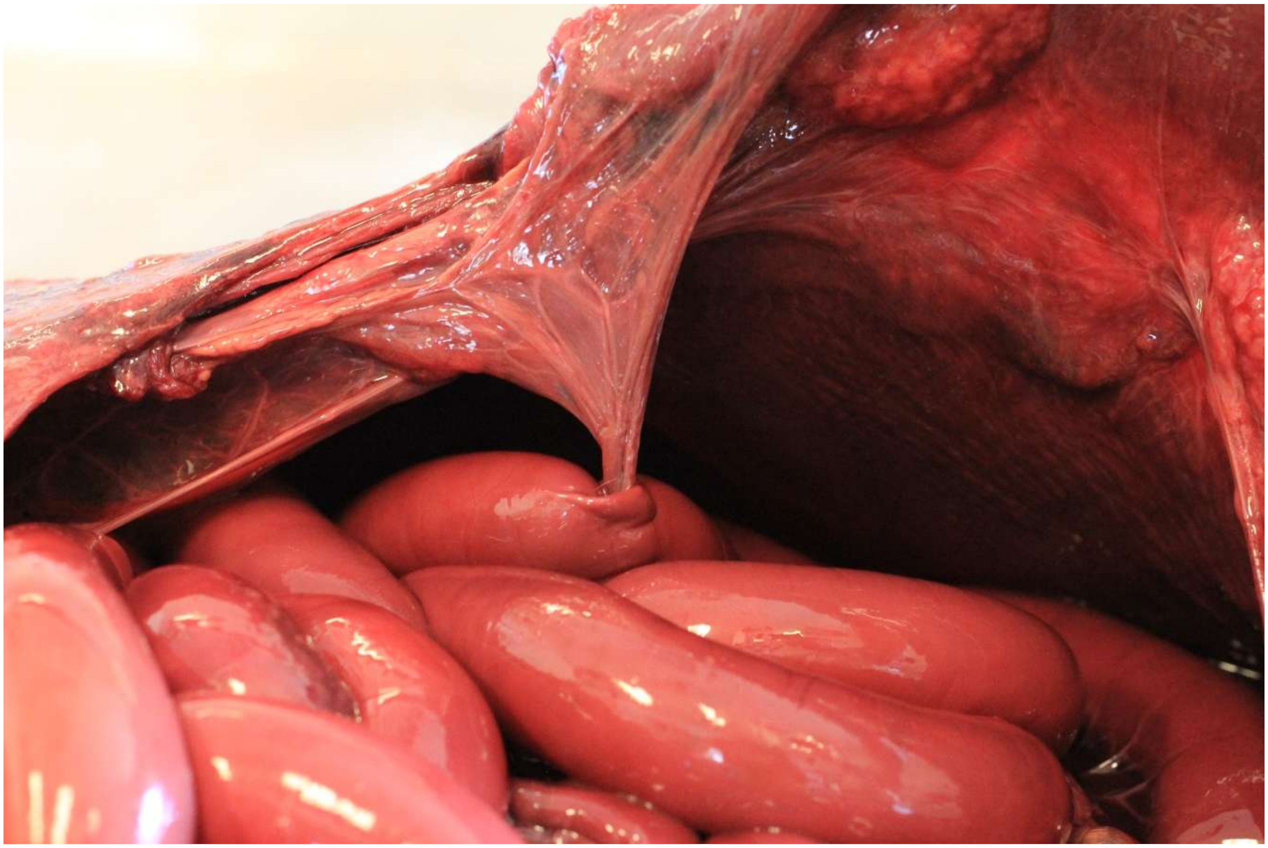
2) Patchy wet and partially sloughing pelage (PHOTO)
3) Mild nasopulmonary acariasis, nasal cavity
4) Possible accessory spleens in omentum (Possible prior non-fatal splenic trauma?)-No accessory spleens observed on HP
5) Mitral and aortic valve WNL, foramen ovale closed
6) Probable mature protozoal tissue cyst (sarcocyst), myocardial LVFW near papillary MM (PHOTO)

COMMENT

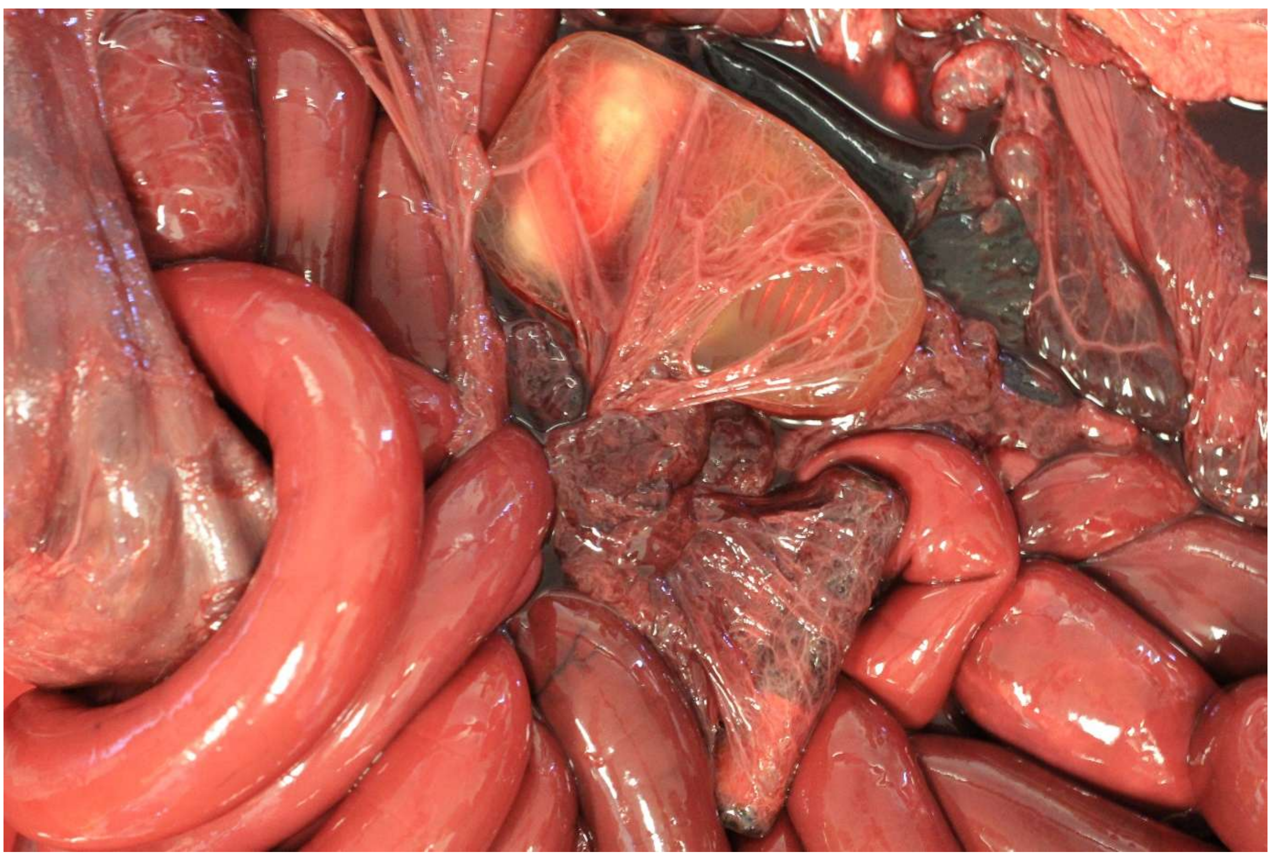
Findings from gross necropsy and histopathology are strongly suggestive of death due to complications of omental entrapment of a surgically-placed TDR and VHF transmitter. Although the TDR had been surgically placed inside of the falciform ligament, it was found inside of the omental bursa at necropsy. A small fibrous adhesion of the omentum to the falciform ligament is supportive of post-operative TDR extrusion into the peritoneum. No adhesions were apparent at the midline surgical incision. Over time, both instruments passed into the omental bursa, and then moved to the outer edge of this sac-like tissue at different locations. The weight of these instruments at the outer portion of the omentum contributed to progressive torsion/twisting of adjacent omentum (e.g. “boloing”) into two separate, but intertwined tissue stalks, each containing an instrument (e.g. VHF or TDR) at the outer edge. The stalk associated with the VHF transmitter was especially long and tightly twisted. Multifocal instrument entrapment and subsequent torsion contributed to severe omental infarction and multifocal intestinal entrapment by the heavily weighted, twisted and freely moveable omental “bolos”, with contributing impacts by the omental-falciform adhesion.

Segments of entrapped small and large intestine developed progressive proximal intestinal impaction and mural vascular compromise, leading to segmental mesenteric edema. Omental, intestinal and mesenteric compromise contributed to the development of serofibrinous peritonitis, and possibly, perimortem sepsis. Moderate to severe omentitis was confirmed in multiple sections of omentum on histopathology, including the brown, friable portions associated with the instrument entrapments. Marked mesenteric venous congestion, and possible marked intestinal mucosal congestion, and mesenteric edema and hemorrhage were also noted on histopathology. The extent of antemortem omental or intestinal infarction could not be accurately assessed due to severe postmortem autolysis. Marked postmortem bacterial proliferation also obscured the ability to confirm antemortem bacterial peritonitis. No gross or microscopic evidence of acanthocephalan peritonitis was found in multiple sections of intestine, mesentery or omentum at necropsy or via histopathology. This animal died in good nutritional condition, suggesting that although the sequence of events leading to death took some time to develop, the final steps progressed relatively rapidly.

Mild/moderate cardiomyopathy was confirmed on histopathology. There was no clear evidence of congestive heart failure, but advanced autolysis precluded precise assessment. The area of red-black discoloration that was noted grossly along the coronary groove (PHOTO) appeared to be an area of peri/ PM fluid leakage +/- serous atrophy of coronary adipose on HP.

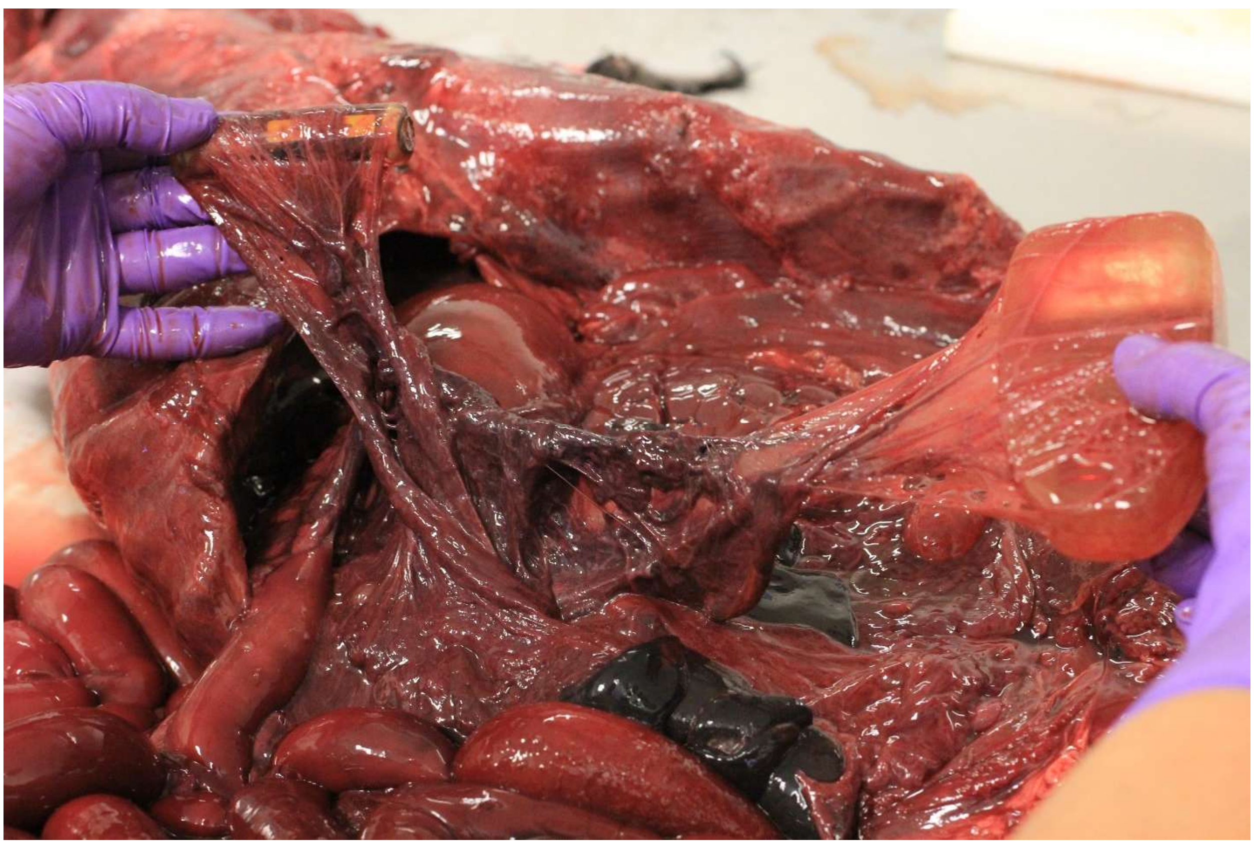


Fibrous adhesion connecting the omentum to the falciform ligament

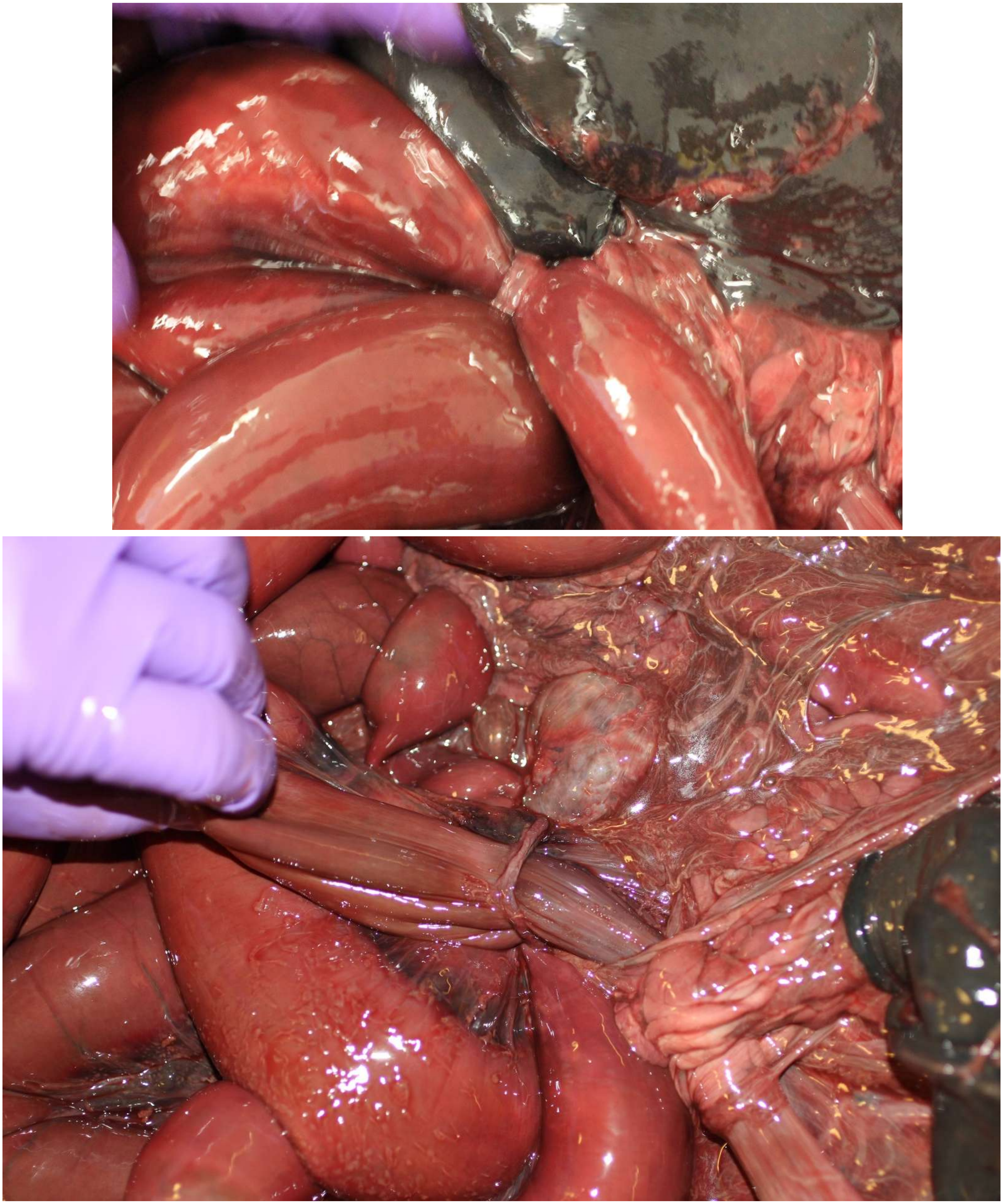


TDR and VHF entrapped in the omental bursa with subsequent twisting and “bolo” formation

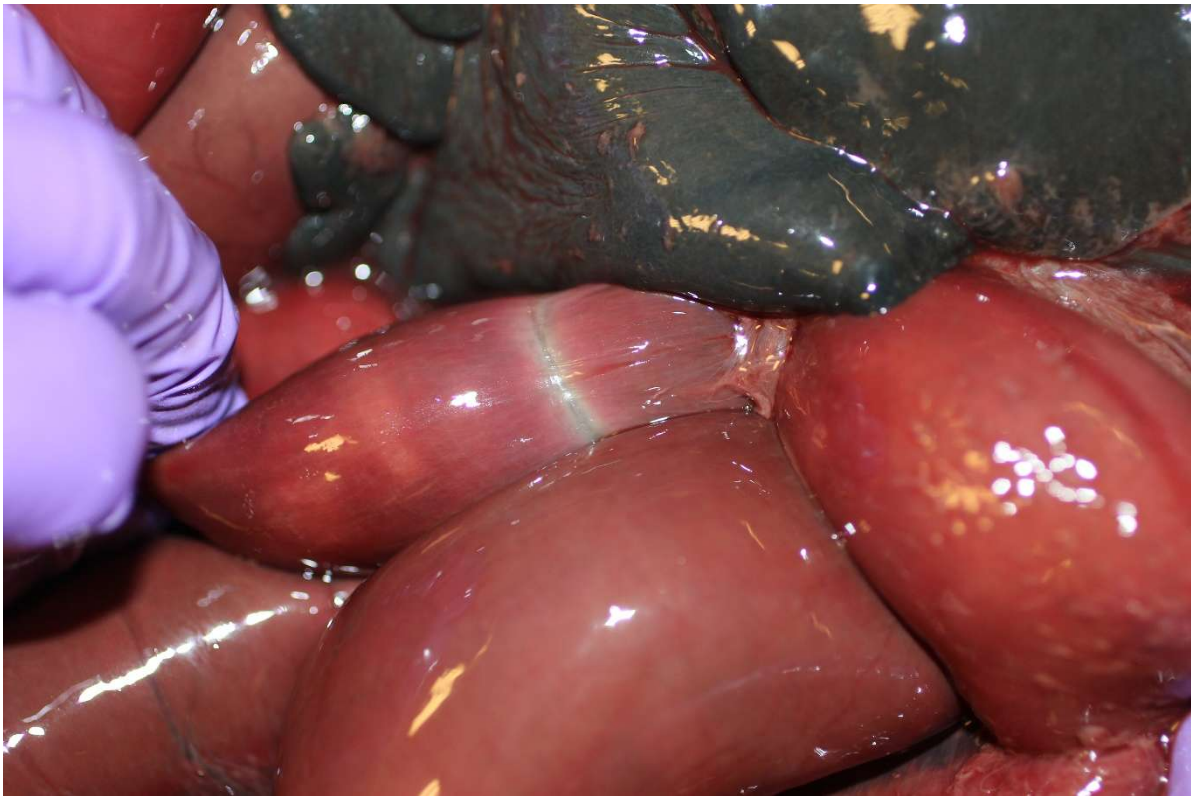
The omentum below the VHF transmitter was tightly twisted into a long stalk

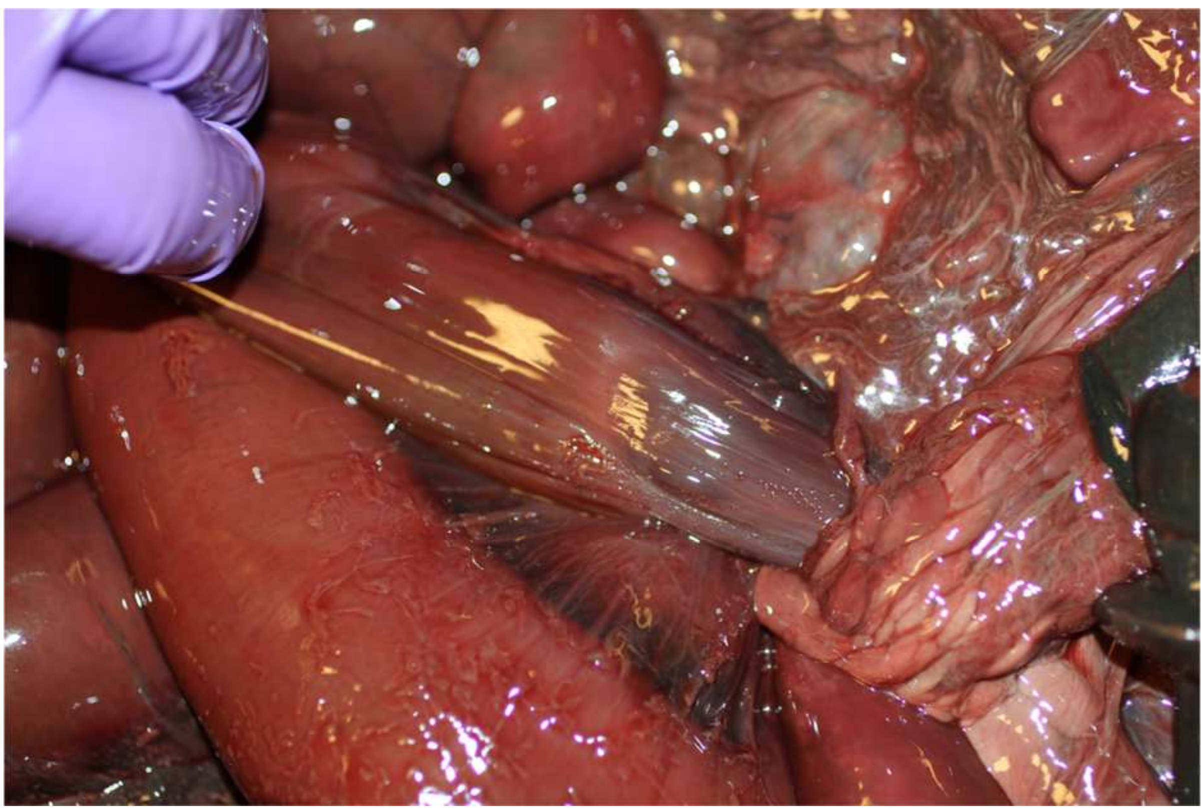


The omentum at the base of the VHF and TDR-associated omental twists was dark brownish-red and friable (omental necrosis, pres.)

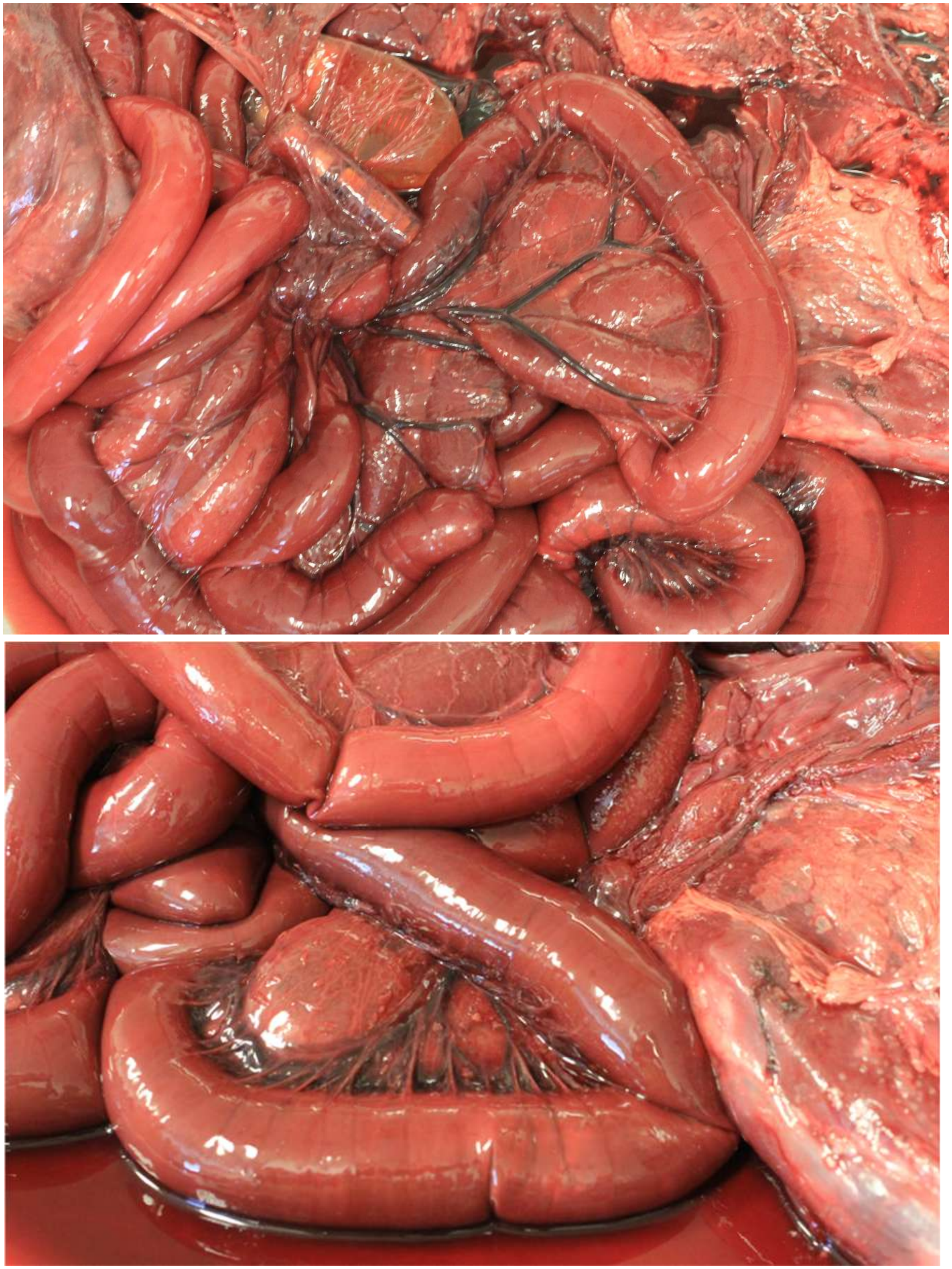


Two different (small and large intestinal, respectively) sites of intestinal constriction and proximal intestinal impaction following omental entrapment.

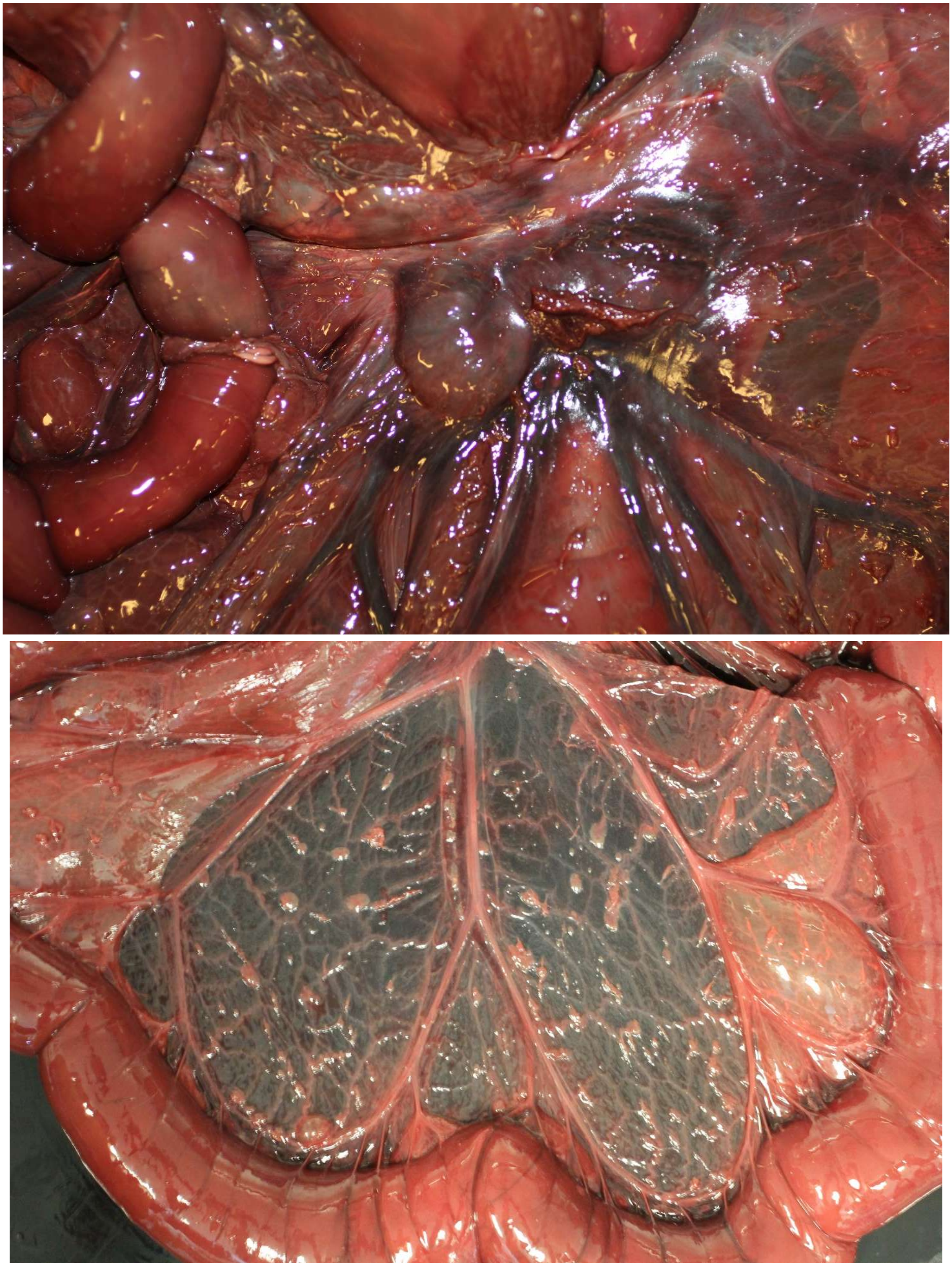




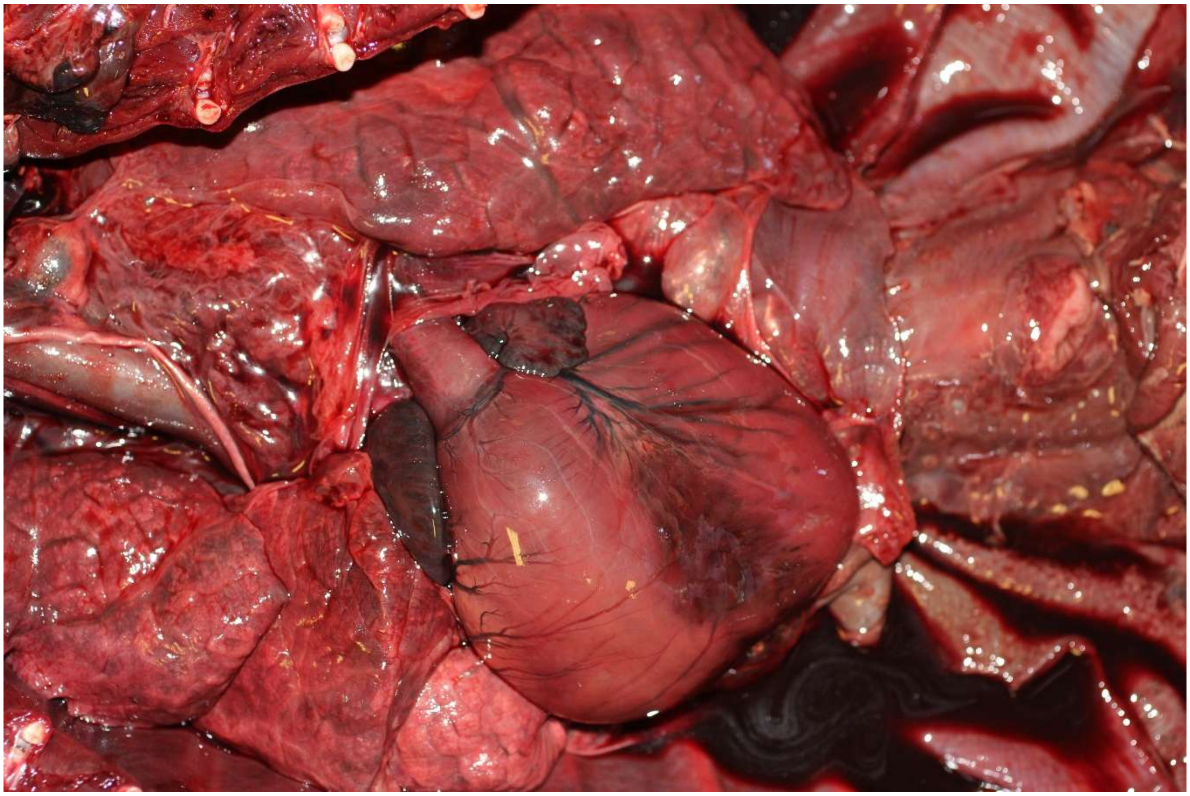
Minimal to marked serosal pallor and luminal constriction was apparent after the omental bands were removed. Also note perilesional serosal fibrin tags in lower photo.

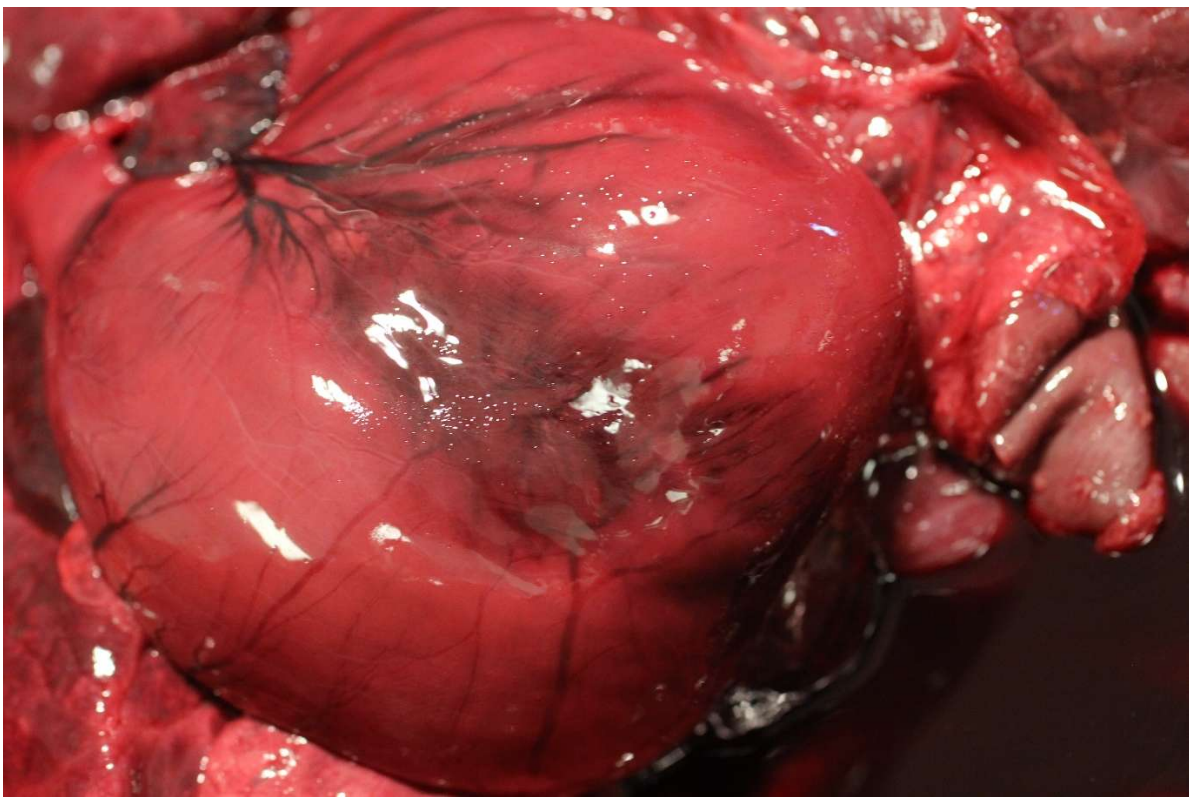


The mesentery was congested and edematous proximal to regions of intestinal constriction/impaction

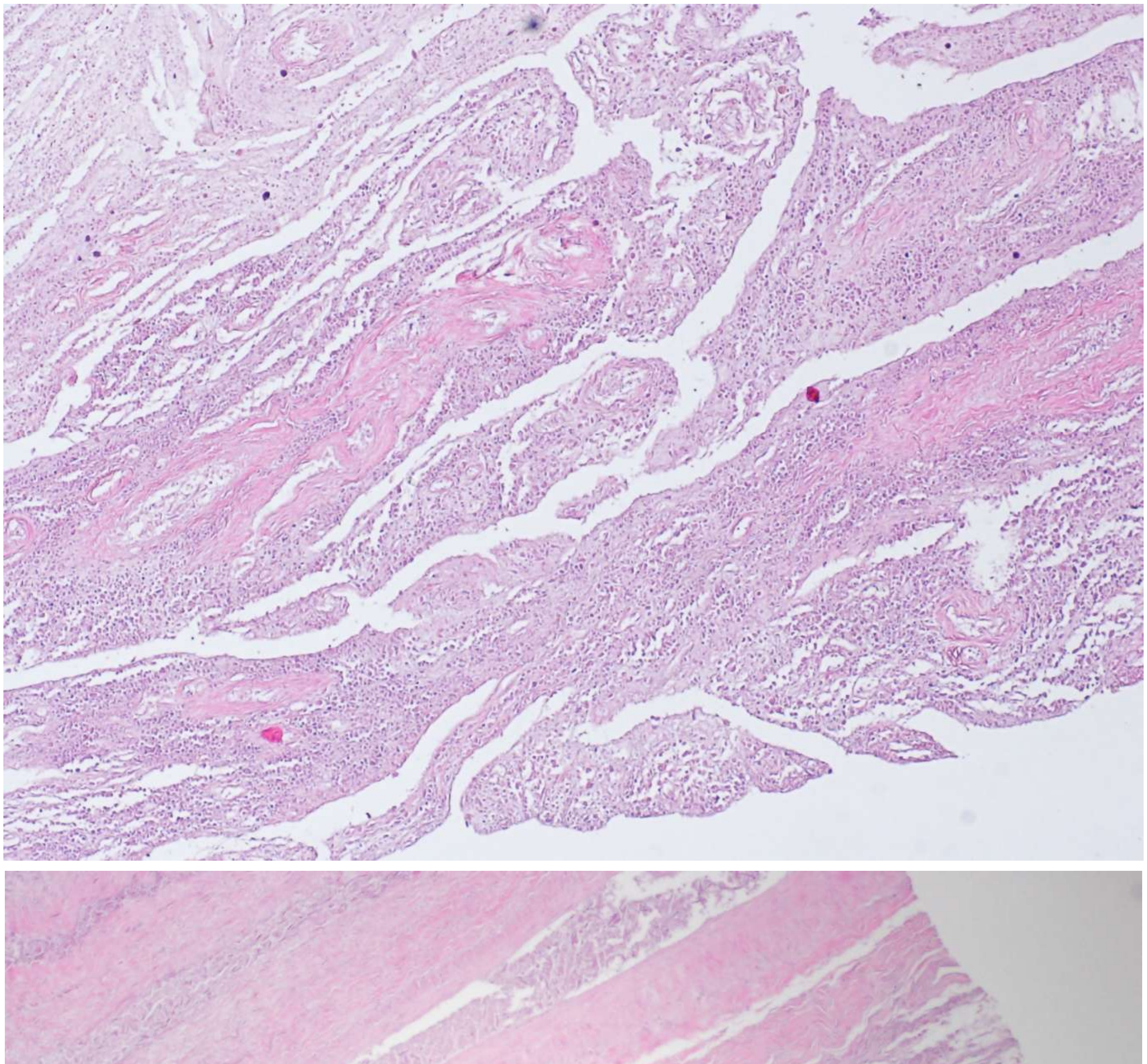


Free-floating masses of fibrin (above) and adherent fibrin tags (below) were apparent in the affected areas.

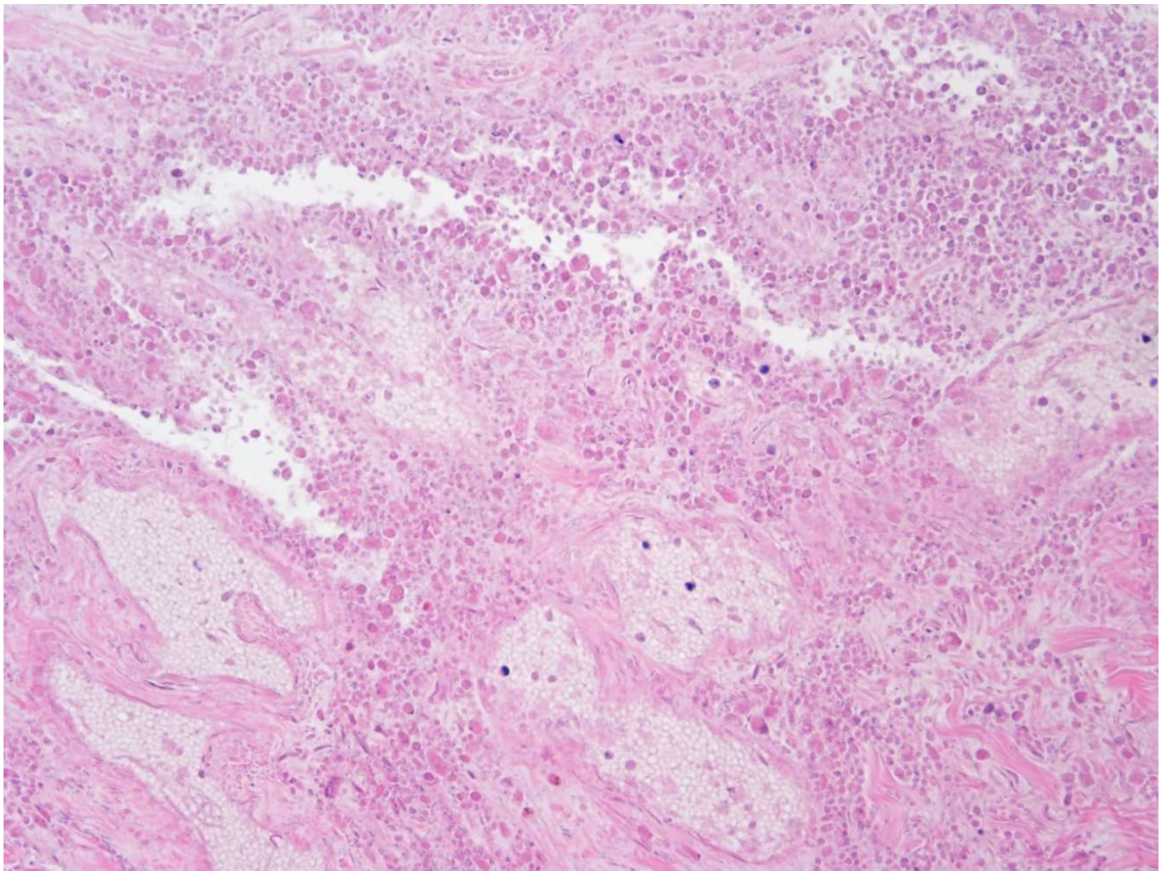


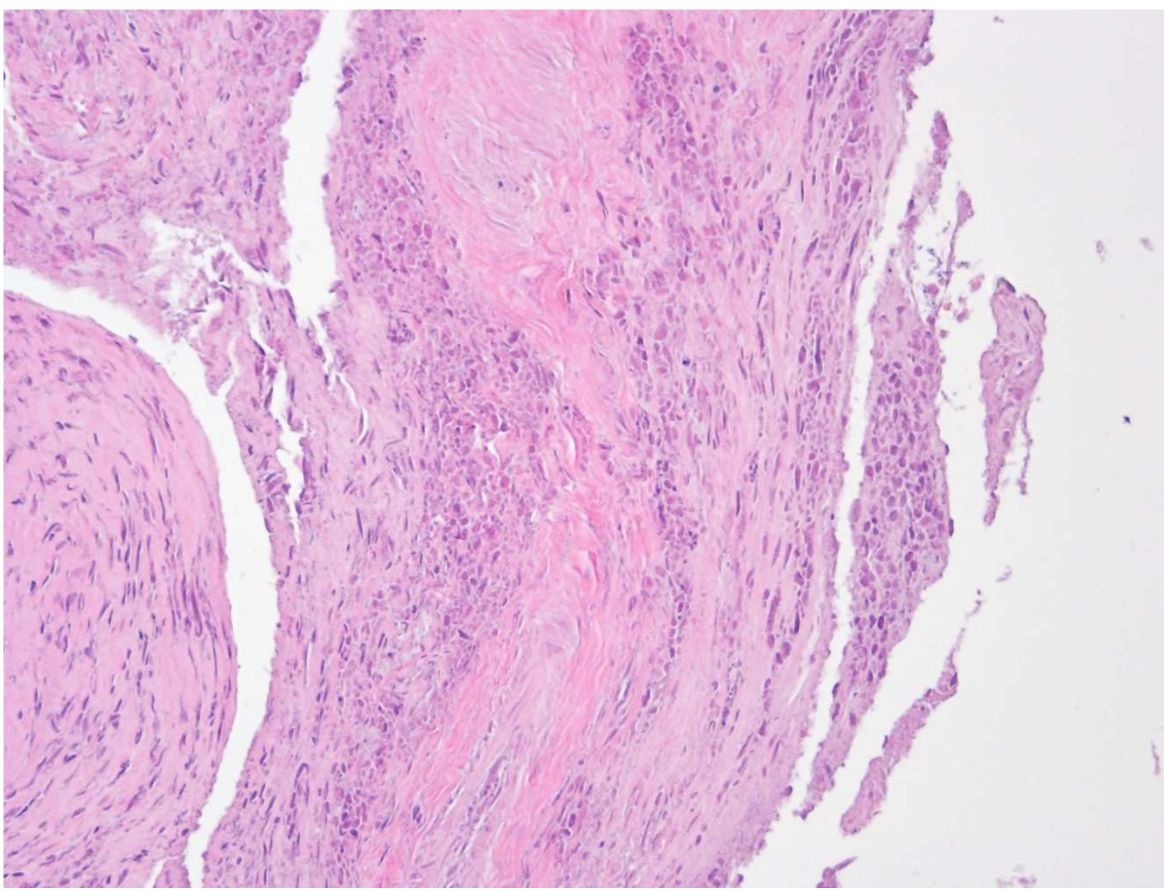


The heart was dilated with a prominent double apex, and the myocardium was diffusely pale. A region of reddish-black tissue discoloration was apparent along the junction between the left and right ventricles

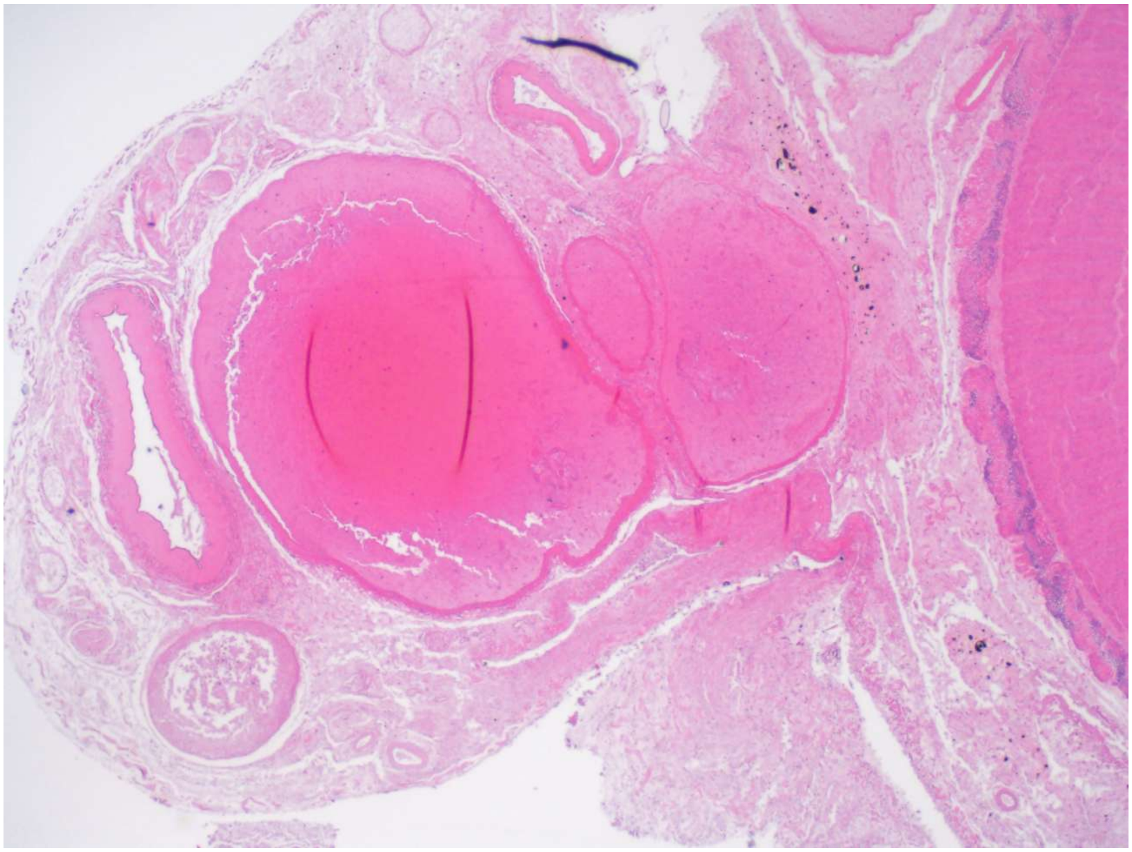


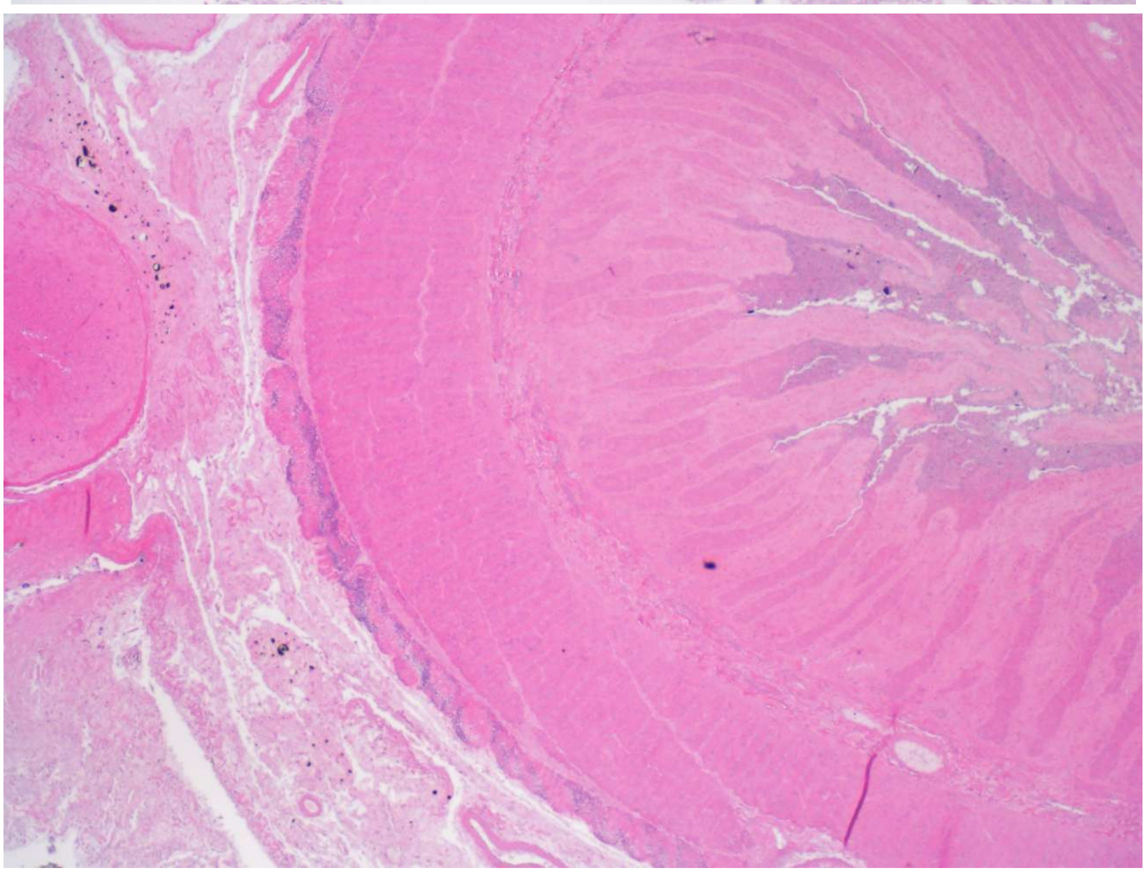
<u>Histology:</u> Inflamed omentum from the TDR (top) & VHF transmitter entrapment points (bottom)



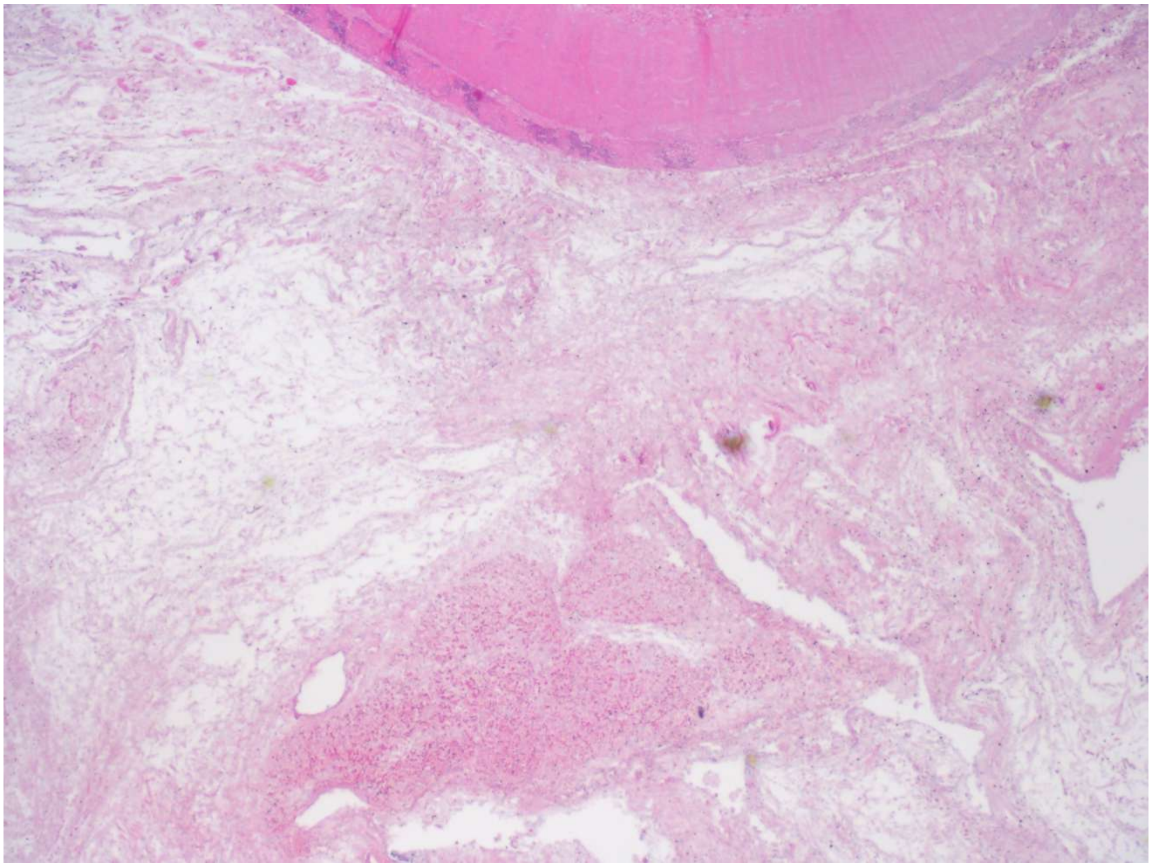
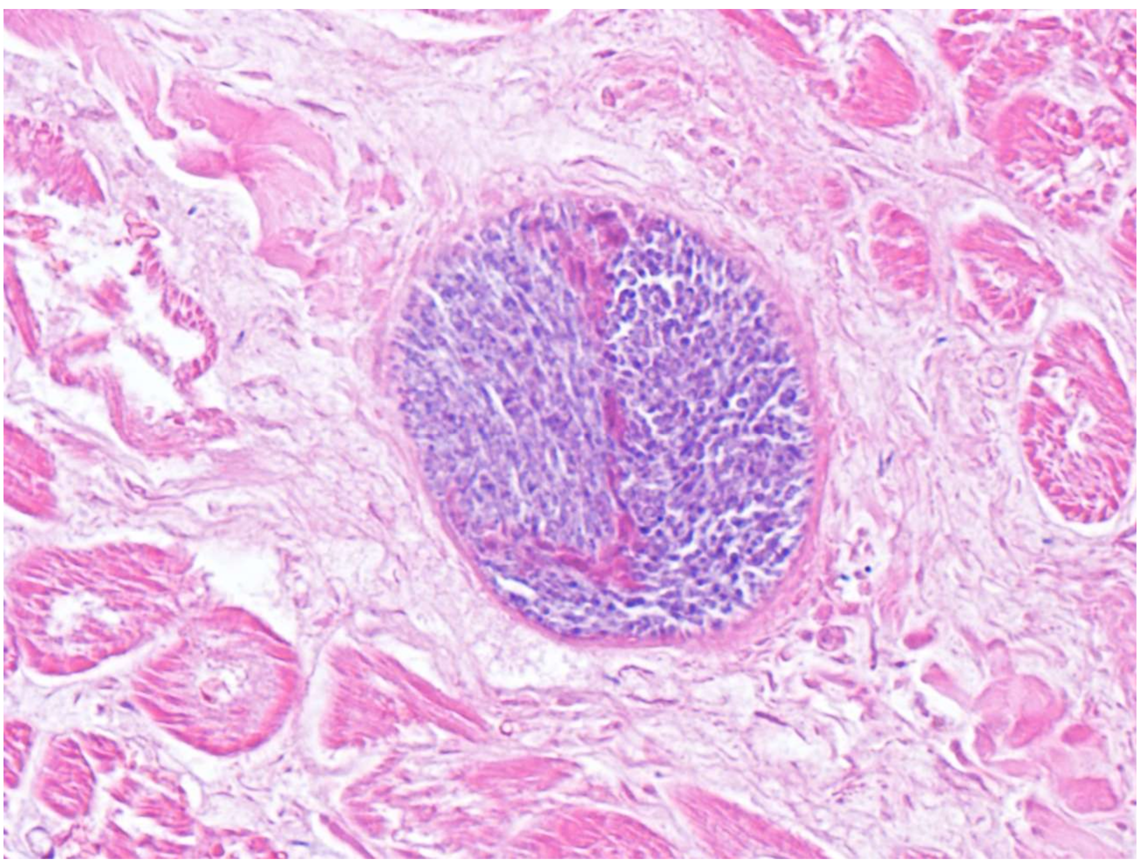


Inflamed omentum from the region of brown, friable omentum noted grossly (both), with possible surface exudate (bottom)





Marked mesenteric venous congestion (top) and possible severe mucosal congestion, small intestine (bottom)



Possible mesenteric hemorrhage & edema near intestine, same area as above photos (top)
Possible protozoal tissue cyst (sarcocyst), myocardium (bottom)

HISTOPATHOLOGY:

Letter	Tissue	Comment	PathologistComment
All tissues			Marked diffuse autolysis with PM bacterial proliferation
A	Cerebrum & cerebellum		WNL. Tissue is highly fragmented. Mild/mod congestion. Possible mild capillary neutrophilia.
B	Cerebellum & brainstem		WNL. Tissue is highly fragmented. Mild/mod congestion. Possible mild capillary neutrophilia. Large gas bubbles.
C	Lung		WNL. Severe autolysis with large gas bubbles.
C	Cerebellum		WNL. Tissue is highly fragmented. Mild/mod congestion. Possible mild capillary neutrophilia. Large gas bubbles.
D	Lung		WNL. Severe autolysis with large gas bubbles & bacterial proliferation. Possible antemortem septal edema.
E	Heart	Aorta	WNL
E	Heart	Right Ventricle Papillary Muscle	WNL. Possible mild patchy myofiber dropout with associated interstitial fibrosis? Marked postmortem mixed bacterial proliferation.
F	Heart	Right Ventricle Papillary Muscle	WNL. Possible mild/mod patchy myofiber dropout with associated interstitial fibrosis? Marked postmortem mixed bacterial proliferation.
F	Heart	Right A/V	WNL. Possible mild/mod patchy myofiber dropout with associated interstitial fibrosis? Marked postmortem mixed bacterial proliferation.
G	Heart	Left Ventricle Papillary Muscle	WNL. Mild patchy myofiber dropout with associated interstitial fibrosis. Marked postmortem mixed bacterial proliferation. Possible mild endocardial suppurative inflammation? Mild valvular endocardiosis. Large gas bubbles.
G	Heart	Septum	WNL. Mild patchy myofiber dropout with associated interstitial fibrosis. Marked postmortem mixed bacterial proliferation. Possible mild endocardial suppurative inflammation? Mild valvular endocardiosis. Large gas bubbles.

H	Heart	Left Ventricle Papillary Muscle	WNL. Possible mild patchy myofiber dropout with associated interstitial fibrosis. Marked postmortem mixed bacterial proliferation. Large gas bubbles.
H	Heart	Left A/V	WNL. Possible mild patchy myofiber dropout with associated interstitial fibrosis. Marked postmortem mixed bacterial proliferation. Large gas bubbles.
I	Heart	Left A/V	Focally extensive possible antemortem epicardial hemorrhage. Possible mild patchy myofiber dropout with associated interstitial fibrosis. Marked postmortem mixed bacterial proliferation. Large gas bubbles.
I	~~Mammary tissue~~	~~Pink in middle~~	Not present on slide
J	Heart	Left Ventricle Papillary Muscle	Moderate patchy myofiber dropout with associated interstitial fibrosis. Focal intracytoplasmic protozoal tissue cyst in adjacent LVFW (Likely sarcocyst-PHOTO). Marked postmortem mixed bacterial proliferation. Large gas bubbles.
J	Heart	Heart bruising	WNL. Moderate serous atrophy of adipose in poss. Area of "hemorrhage?". Possible mild patchy myofiber dropout with associated interstitial fibrosis. Marked postmortem mixed bacterial proliferation. Large gas bubbles.
K	Heart	Left Ventricle Papillary Muscle	Moderate patchy myofiber dropout with associated interstitial fibrosis. Marked postmortem mixed bacterial proliferation. Large gas bubbles.
K	Heart	Left A/V	Mild patchy myofiber dropout with associated interstitial fibrosis (incl. atrial wall). Marked postmortem mixed bacterial proliferation. Large gas bubbles.
L	Heart	Apex	Mild/mod patchy myofiber dropout with associated interstitial fibrosis (esp. septum & LVFW). Marked postmortem mixed bacterial proliferation. Large gas bubbles.
M	Heart	Heart bruising	"Bruising" corresponds with area of focally ext. proteinacious perivascular fluid leakage (Unk if antemortem or PM) and serous atrophy of coronary adipose. Mild patchy myofiber dropout with associated interstitial fibrosis.

N	Heart	Heart bruising	"Bruising" corresponds with area of focally ext. proteinacious perivascular fluid leakage (Unk if antemortem or PM) and serous atrophy of coronary adipose. Mild+ patchy myofiber dropout with associated interstitial fibrosis.
O	Adrenal Gland	Right, 2 sections	WNL. Gas bubbles.
O	Kidney	Right	WNL. Possible mild cortical thinning and minimal papillary tubular mineralization.
P	LN Axillary	Left	WNL? Severe autolysis.
P	Adrenal Gland	Left, 2 sections	WNL. Gas bubbles.
Q	Kidney	Left	WNL. Possible mild cortical thinning and minimal papillary tubular mineralization.
R	Omentum	Healthy omentum, 5 sections	Omentum is moderately to markedly thickened and hypercellular, with probable expansion by macrophages +/- other inflammatory cells (unable to determine cell types due to severe autolysis and bacterial proliferation) (PHOTO). Sparse areas of remaining mesothelium appear tall and hypertrophic (PHOTO). In some areas the omental structure is diffusely pale eosinophilic (due to severe autolysis, unable to confirm whether this associated with antemortem omental infarction or is all PM autolysis) (PHOTO).
S	Omentum	Unhealthy omentum, 6 sections	The tissue is highly fragmented and is moderately to markedly expanded by dense sheets of inflammatory cells (PHOTO). In some areas there is a surface coating of inflammatory cells, cell debris and proteinacious material (fibrin?) (PHOTO). Mixed bacteria are abundant. No residual fragments of acanthocephalans are apparent in any omental section.
T	Intestinal Contents	3 sections, 1 from each piece of intestine sampled	There is marked diffuse mesenteric (+/- mucosal?) venous congestion in two of the three sections (PHOTO). Areas of more severe mesenteric vascular congestion are associated with areas of possible mesenteric hemorrhage and edema (PHOTO).
U	LN Mesenteric		Severe autolysis & gas bubbles.
U	Spleen		Severe autolysis & gas bubbles.
V	Tongue	2 sections	Possible intranuclear viral inclusions associated with mild hyperkeratosis.

W	Liver	1 section each cassette, only one piece of liver sampled, not specified left or right	Marked diffuse autolysis with multiple large gas bubbles.
X	Liver	1 section each cassette, only one piece of liver sampled, not specified left or right	Marked diffuse autolysis with multiple large gas bubbles.
Y	Liver	1 section each cassette, only one piece of liver sampled, not specified left or right	Marked diffuse autolysis with multiple large gas bubbles.
Z	Stomach	2 sections each cassette, body sections to pyloric sections	Marked diffuse autolysis.
AA	Stomach	2 sections each cassette, body sections to pyloric sections	Marked diffuse autolysis.

BB	Stomach	2 sections each cassette, body sections to pyloric sections	Marked diffuse autolysis.
CC	Abdominal Wall	Surgical site, 3 sections	Mildly inflamed adhesion on peritoneal surface of 1/3 sections.
DD	Mesentery, omentum, intestine	~~Mesentery with acanths?, 2 - 3 sections~~	Several sections of variably inflamed and congested omentum (pres.), mesentery and severely autolyzed intestine. No sections of acanthocephalans are apparent.
EE	Intestine	Intestine with fibrin?, 3 sections	Several sections of severely autolyzed intestine with variable (mild-severe) mural congestion. No sections of acanthocephalans are apparent.
FF	Intestine	Intestine with fibrin?, 2 sections	Several sections of variably inflamed and congested omentum (pres.), mesentery and severely autolyzed intestine. No sections of acanthocephalans are apparent.
GG	Omentum	Omentum attached to abdominal wall, 4 sections	Several sections of variably inflamed and congested omentum (pres.). No sections of acanthocephalans are apparent.
HH	Omentum	TDR pocket, 7 sections	Several sections of variably fragmented and severely inflamed and congested omentum (pres.) with possible surface exudate (PHOTO). Possible patchy mural fibroplasia/granulation tissue. No sections of acanthocephalans are apparent.
II	Omentum	VHF pocket, 8 sections	Several sections of variably fragmented and severely inflamed and congested omentum (pres.) with possible surface exudate (PHOTO). Possible patchy mural fibroplasia/granulation tissue (PHOTO). No sections of acanthocephalans are apparent.

JJ	Abdominal Wall	Adhesion site on abdominal wall	Section of mild/moderately inflamed omentum (pres.) with possible surface exudate attached to ventral body wall (minus integument). Patchy mild fibroplasia/granulation tissue. No sections of acanthocephalans are apparent. Inflammation appears to be concentrated on the surface of the omental remnant and ventral abdominal peritoneum
KK	Abdominal Wall	Adhesion site on abdominal wall	Section of mild/moderately inflamed omentum (pres.) with possible surface exudate attached to ventral body wall (minus integument). Patchy mild fibroplasia/granulation tissue. No sections of acanthocephalans are apparent. Inflammation appears to be concentrated on the surface of the omental remnant and ventral abdominal peritoneum
LL	Abdominal Wall	Adhesion site on abdominal wall	Section of mild/moderately inflamed omentum (pres.) with possible surface exudate attached to ventral body wall (minus integument). Patchy mild fibroplasia/granulation tissue. No sections of acanthocephalans are apparent. Inflammation appears to be concentrated on the surface of the omental remnant and ventral abdominal peritoneum
MM	Abdominal Wall	Adhesion site on abdominal wall	Section of mild/moderately inflamed omentum (pres.) with possible surface exudate attached to ventral body wall (minus integument). Patchy mild fibroplasia/granulation tissue. No sections of acanthocephalans are apparent. Inflammation appears to be concentrated on the surface of the omental remnant and ventral abdominal peritoneum
NN	Abdominal Wall	Adhesion site on abdominal wall	Section of mild/moderately inflamed omentum (pres.) with possible surface exudate attached to ventral body wall (minus integument). Patchy mild fibroplasia/granulation tissue. No sections of acanthocephalans are apparent. Inflammation appears to be concentrated on the surface of the omental remnant and ventral abdominal peritoneum
OO	Skin	Unspecified piece	WNL. Twisted. No visible mites.

CDFW SEA OTTER NECROPSY REPORT

California Department of Fish and Wildlife
Office of Spill Prevention and Response
Marine Wildlife Veterinary Care and Research Center
151 McAllister Way
Santa Cruz, CA 95060
(831) 469-1719

Sea Otter:	9103-18
UCD PATH:	18S0926
MWVCRC Necropsy	18-0504
Report Date:	11/19/2018
Report Status:	Gross

CASE PROFILE

DFG/BRD#:	1380	**Report By:**	Melissa Miller
UON#:	N-1656-18-S	**Necropsy By:**	Miller, Young, Batac, Dodd, Greenwald
MBA#:		**Necropsy Date:**	11/16/2018
Date Found:	11/15/2018	**Condition:**	Fresh
Condition Found:	Fresh	**Sex:**	Female
Live Strand:	No	**Age Class:**	Adult
Euthanized:	No	**Estimated Age:**	4-6 yrs by M. Miller
Date Died:		**Location:**	Monterey Harbor below Heritage Harbor
Total Length (cm):	121	**County:**	Monterey
Weight (kg):	22.5	**ATOS:**	377
Nutritional State:	Excellent	**DSOFS COD:**	11p
SQ Fat:	Abundant	**Histopathology:**	Full
Food in Gut:	None		

MORTALITY DATABASE CODING

Primary COD:
Possible A/SA DA
intox.
Sequela 1
Abortion
Sequela 2 Aspiration
pneumonia
Secondary COD:
Lymphadenopathy,
Unk cause
Tertiary COD: None
Quaternary COD: None

CASE BACKGROUND

Captured in March 2018 and only tagged because she was pregnant: 3/19/2018, at Monterey Bay Inn, 20.3 kg, 117.5 cm, no VHF/TDR.

She was last seen with 1 tag on 29 Aug 2018 and was regularly resighted between Monterey Bay Inn and the harbor before that. No forage data was recorded for her.

GROSS DIAGNOSES

1.) Possible acute/subacute domoic acid intoxication char. by:

-Marked diffuse vascular congestion and multi-organ congestion (PHOTO)
-Blood-tinged fluid around nose & mouth (PHOTO)
-Hyphema OD>OS
-Brownish, “coffee colored” myocardium and moderately distended, blood-filled atria (PHOTO)
-Pericardial, pleural and mild peritoneal effusion, mild pulmonary edema (PHOTO)
-Possible mild/mod. caudal cerebellar herniation? (PHOTO)

1a.) Abortion/pre-term birth, pres. (Please see below for details) (PHOTO)

1b.) Aspiration pneumonia, left caudal lung lobe, focally extensive, severe, acute/subacute (PHOTO)

1c.) Mild fibrinous pleuritis, left hemithorax (PHOTO)

2.) Mild-marked patchy lymphadenopathy (esp. left retropharyngeal, left axillary, hilar LNs)

FETUS:

1.) Same as #1 above, char. by:
-Pre-term female fetus, head-up position (40.5 cm TL, 1115 gm) (PHOTO)
-Marked pericardial effusion, mild pleural and peritoneal serous effusion (PHOTO)
-Moderate patchy multi-organ congestion (PHOTO)
-Possible epicardial hemorrhage, moderate atrial distension (PHOTO)
-Severe meconium smearing
-Eyes closed, no teeth erupted, moderate to excellent adipose SQ, IP, coronary
-Placental ellipses fused, largest 10.5 x 4 cm
-Fetal membranes intact but partially extruded (~5 cm) into vaginal tract (abortion/parturition) (PHOTO)

INCIDENTAL FINDINGS:

1.) Nasal acariasis, mild

2.) Stage 2 female
-Exc. nutritional condition, abundant SQ, coronary IP adipose (PHOTO)
-Medium white nose wound
-Marked mammary development with scant lactation (PHOTO)
-Mild vulvar swelling (PHOTO)
-Right horn pregnancy, pre-term female fetus, head-up position (40.5 cm TL, 1115 gm) (PHOTO)
-Right ovary: ~1.5 cm CL, no visible CAs, follicles, PO cysts (PHOTO
-Left ovary: Single CA, no CL, follicles, PO cysts (PHOTO)
-Both ovaries ~50% of normal size for adult female (PHOTO)
-Cervix flaccid and fully open
-Uterine cytology (Diffquick): Unremarkable-Mostly sloughed cells and debris (No inflammatory cells, bacteria or other pathogens observed)

-No apparent dystocia, uterine torsion, etc.
-Fetal membranes intact but partially extruded into vaginal tract (abortion/parturition) (PHOTO)

3.) Mild melena

4.) Mild intestinal Corynosoma

GROSS SUMMARY

Pending biochemical testing and microscopic examination of all tissues, acute to subacute domoic acid intoxication is suspected as the cause of death.

Related findings include gross lesions consistent with abortion/premature birth of a female fetus, and aspiration pneumonia.

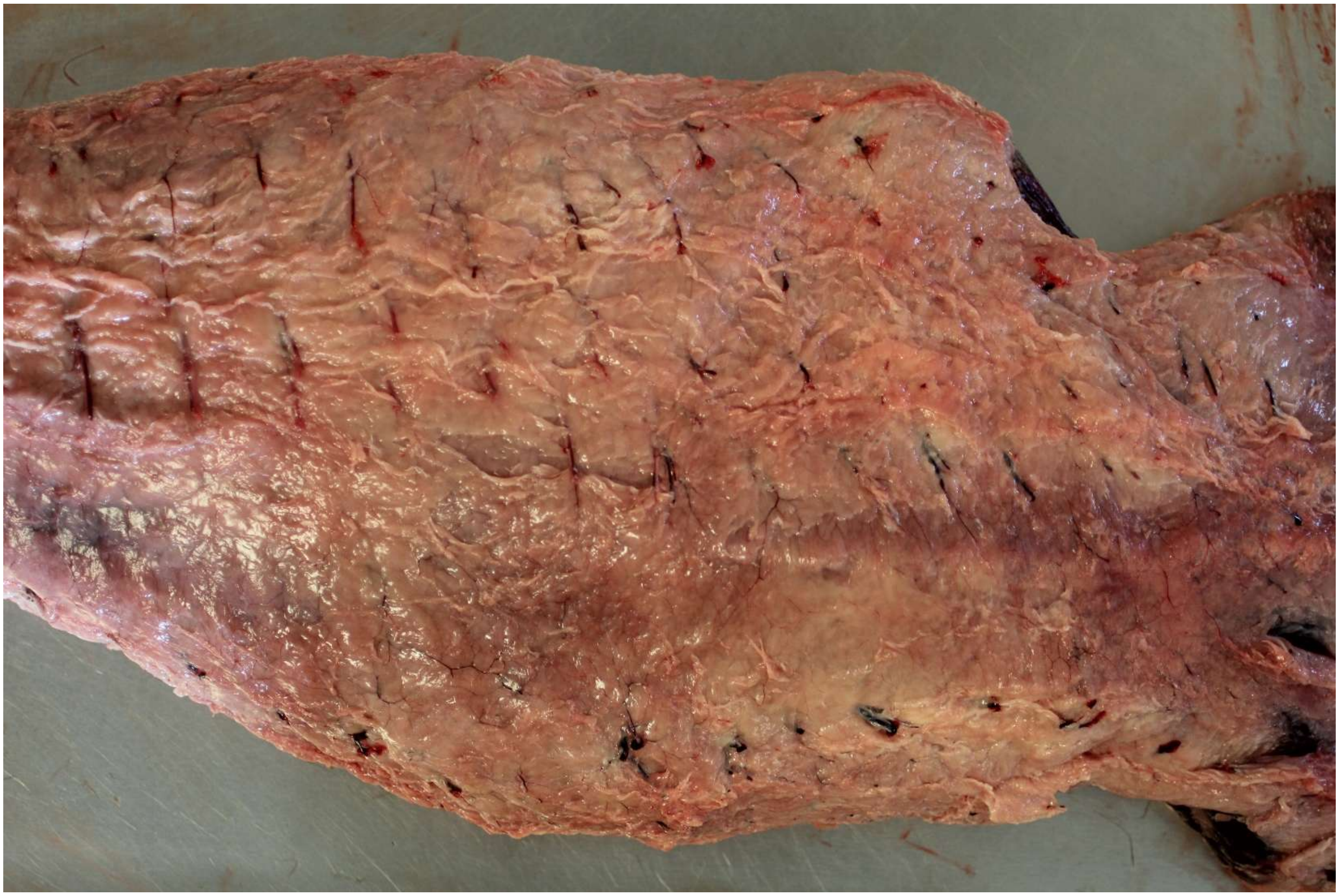
Observed lymphadenopathy may be indicative of concurrent disease-this COD will be updated as part of case completion.

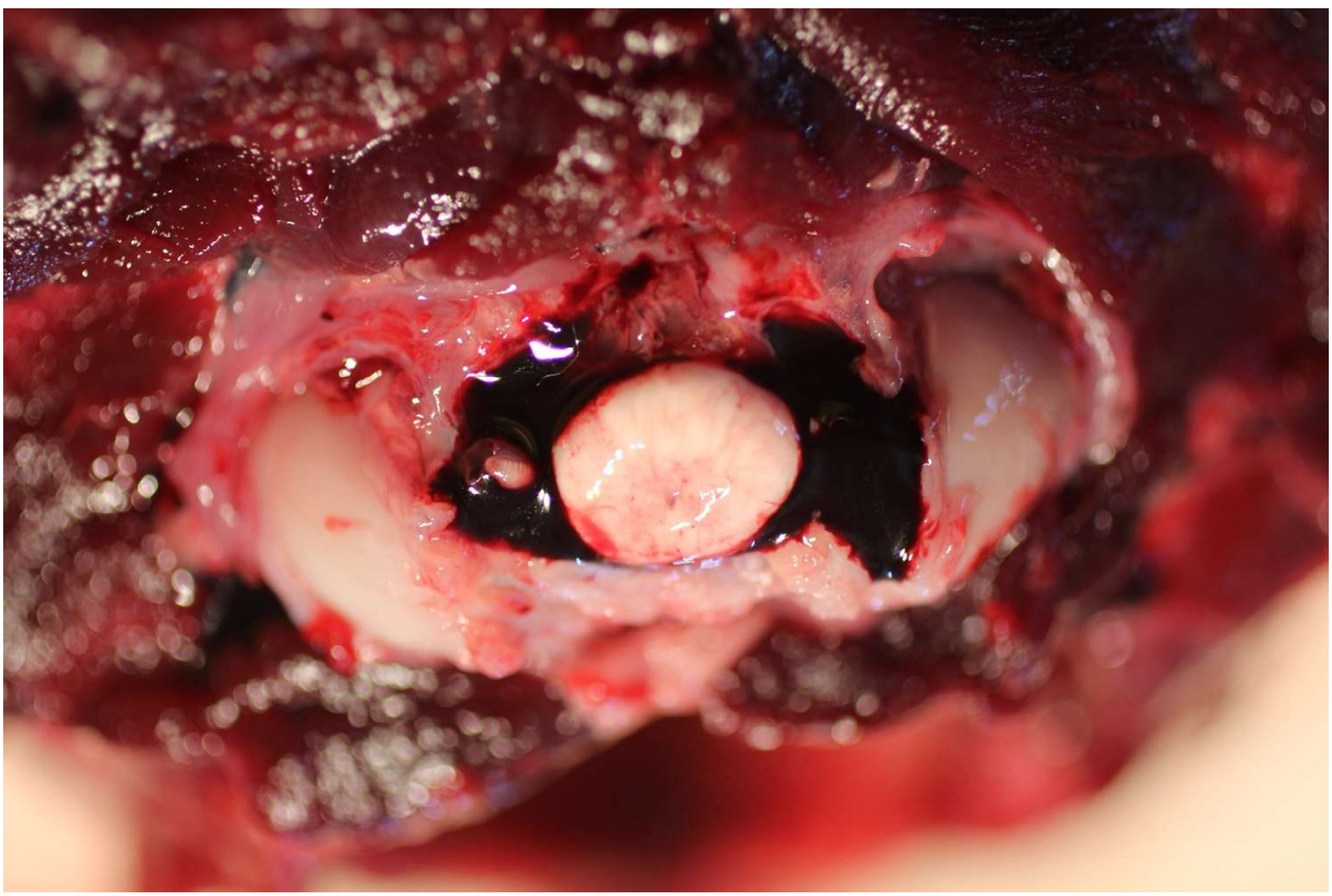
Pending:

- Full HP
- DA testing, maternal & fetal
- Bacterial culture of lung/hilar LN if needed following HP (samples cryoarchived-UCD closed due to Camp Fire)

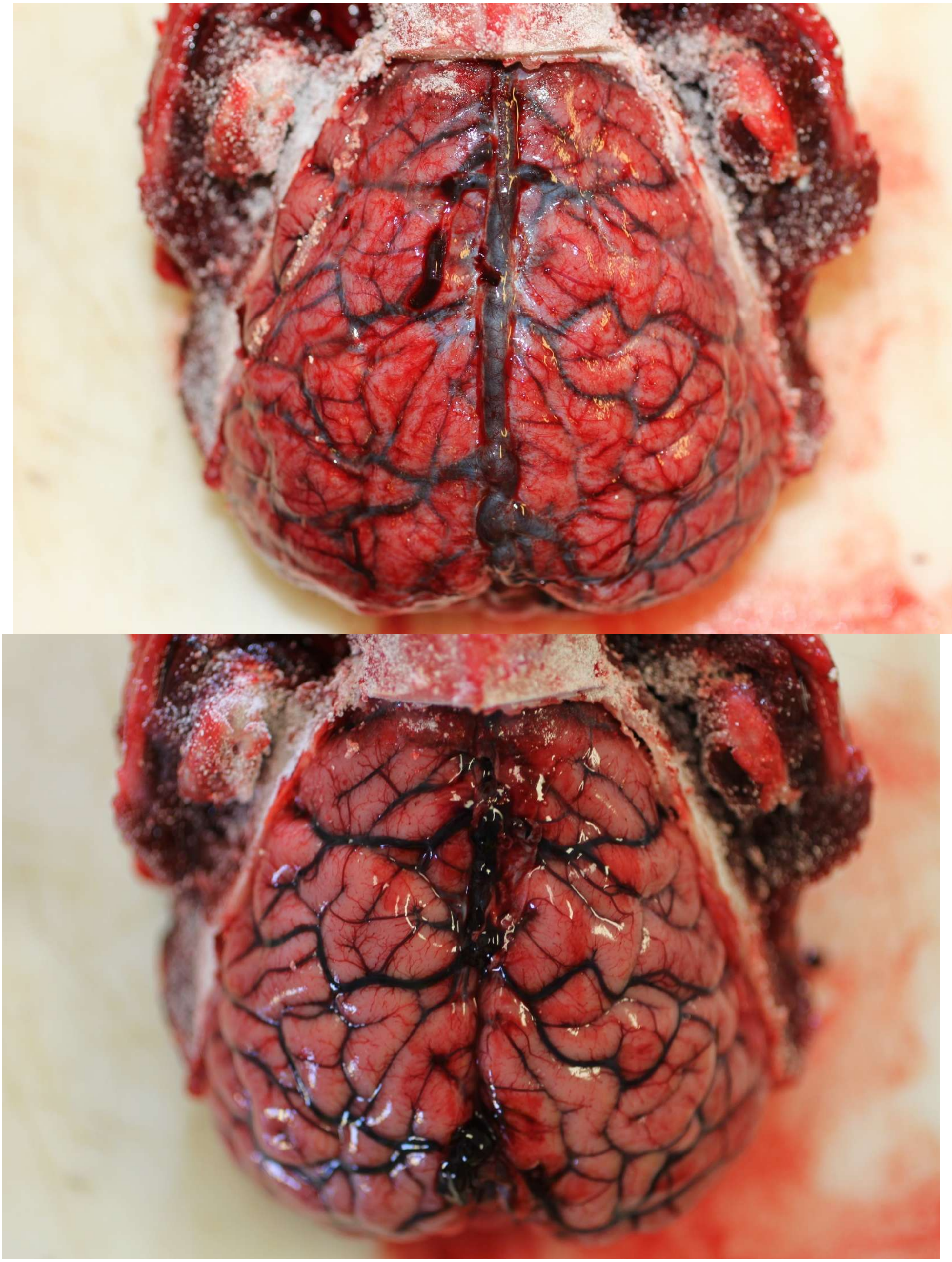
Saved/completed:

- All standard samples (mother and fetus) for cryo-archiving and histopathology
- Numerous gross photos
- Fetal amniotic and allantoic fluid, maternal & fetal upper and lower intestinal content
- Uterine cytology (Diffquick): Unremarkable-Mostly sloughed cells and debris (No inflammatory cells)
- Samples for pelt study (Tometz)

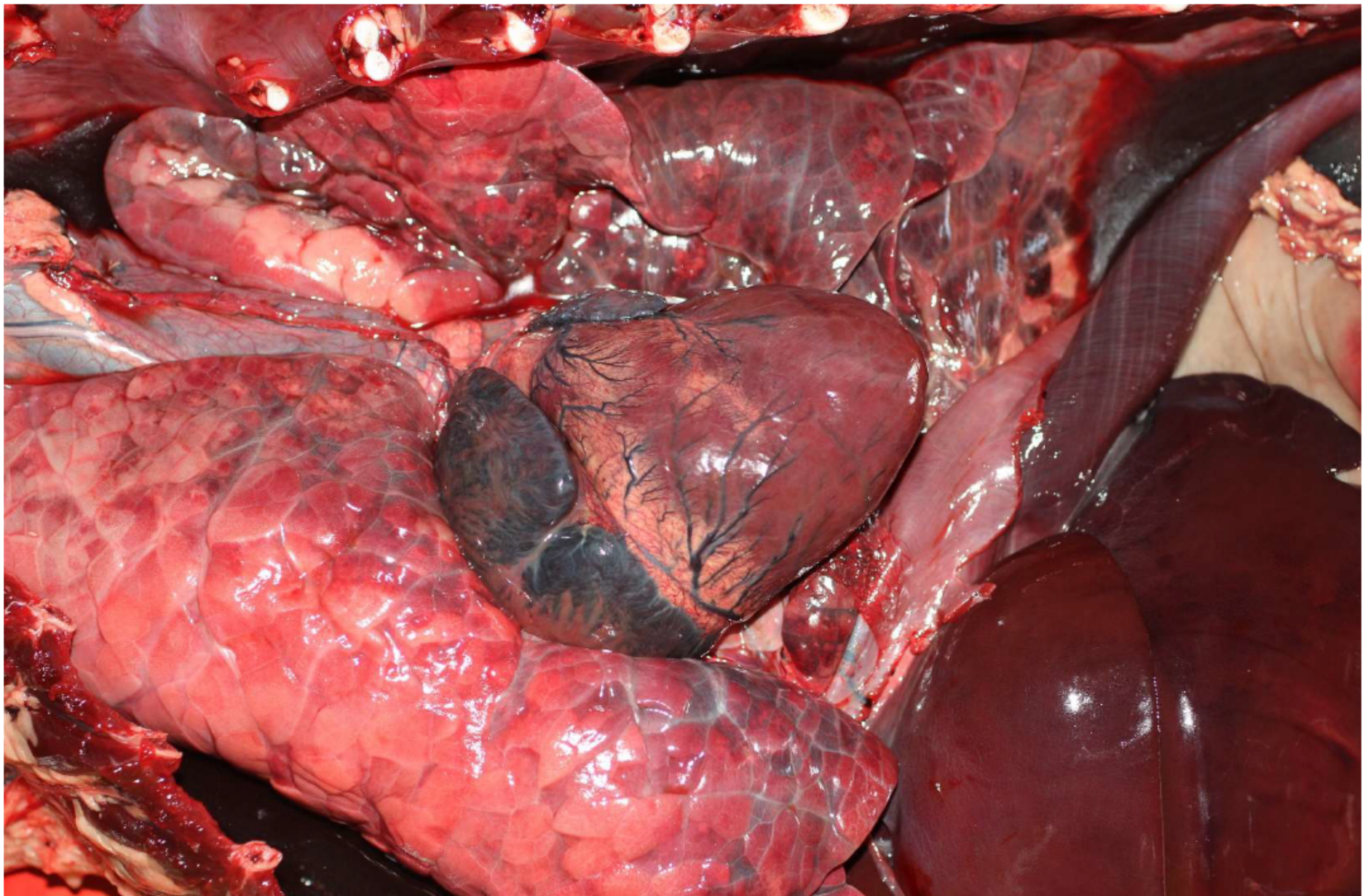


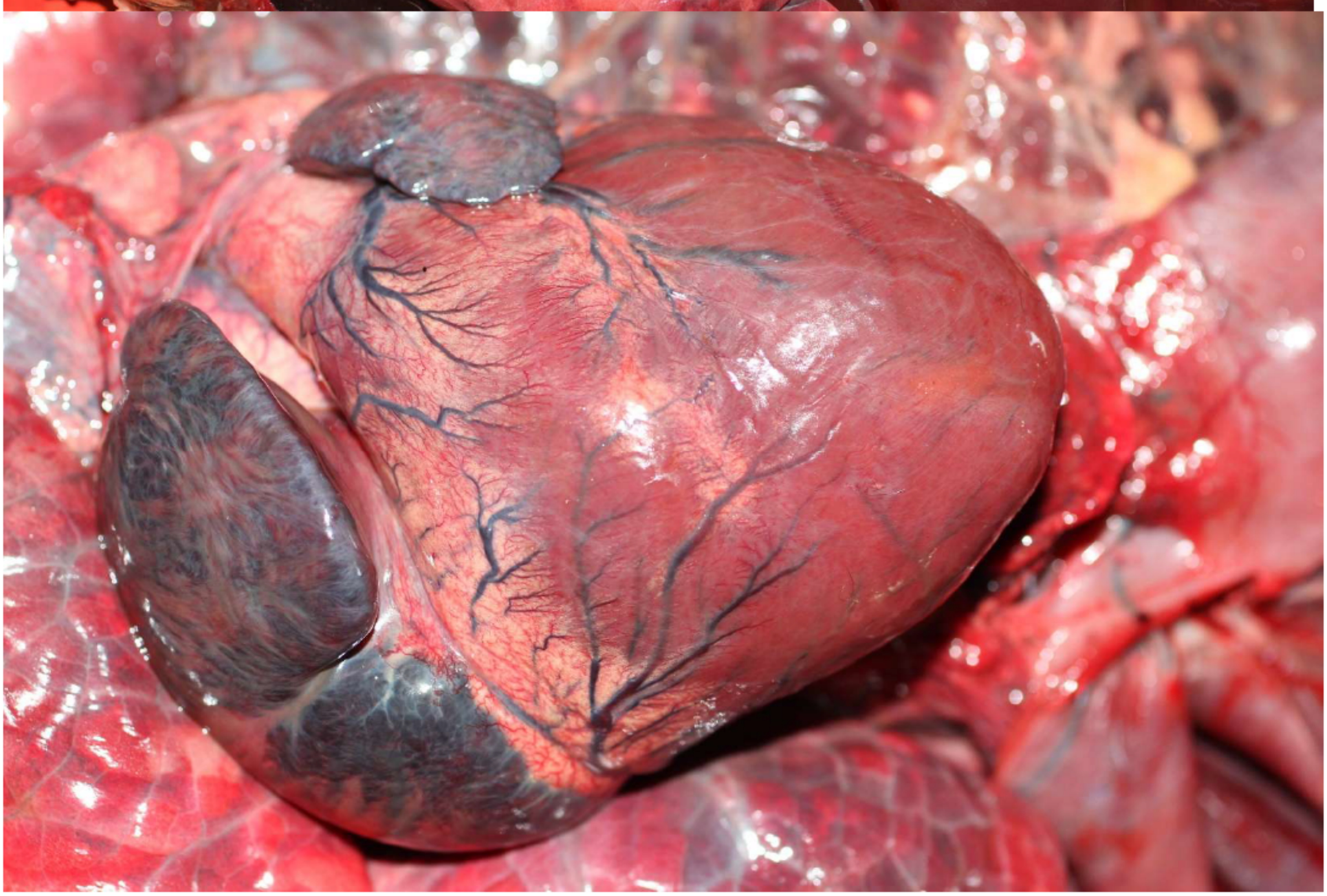


Top: Abundant SQ adipose Bottom: Marked vascular congestion around cervical spinal cord

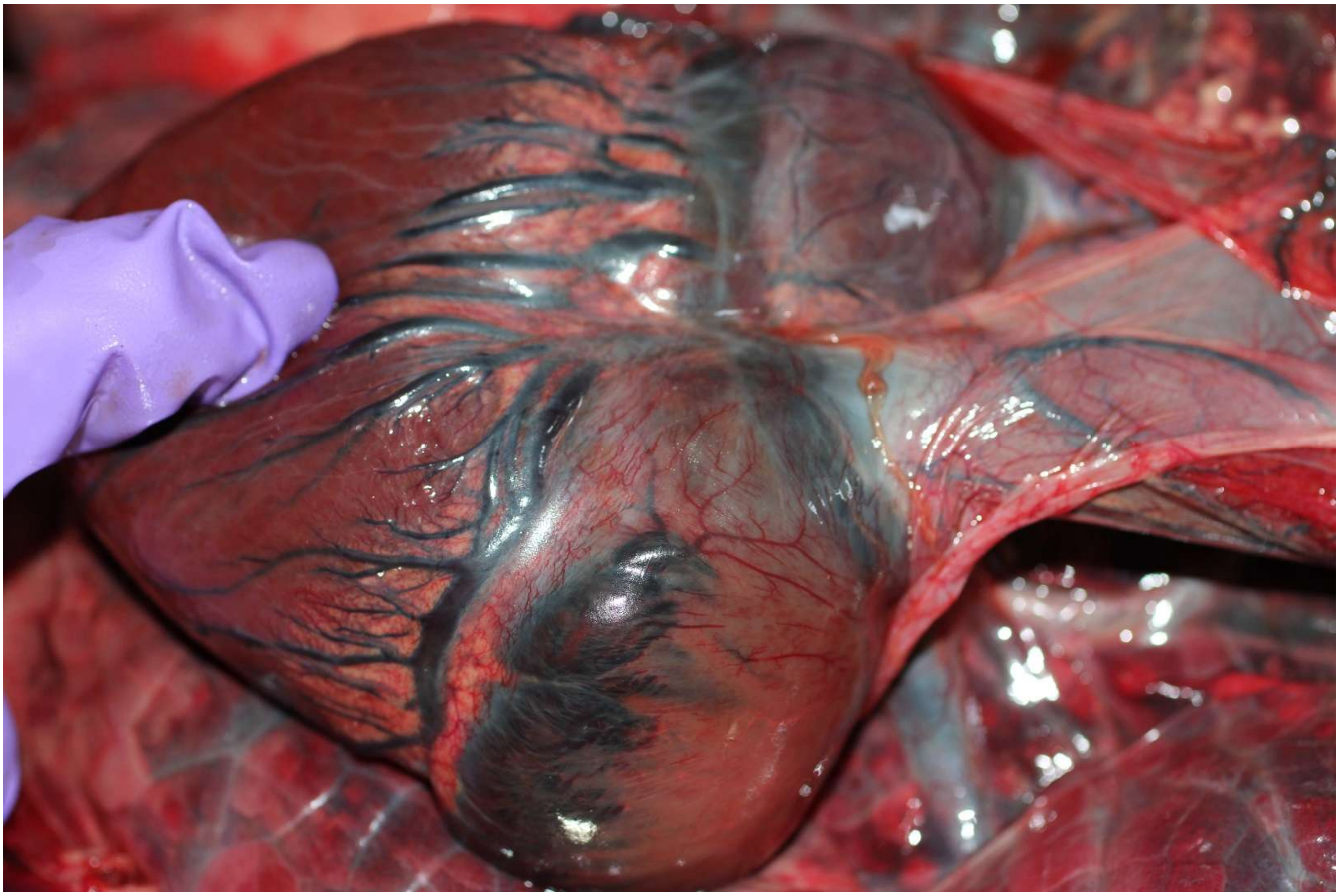


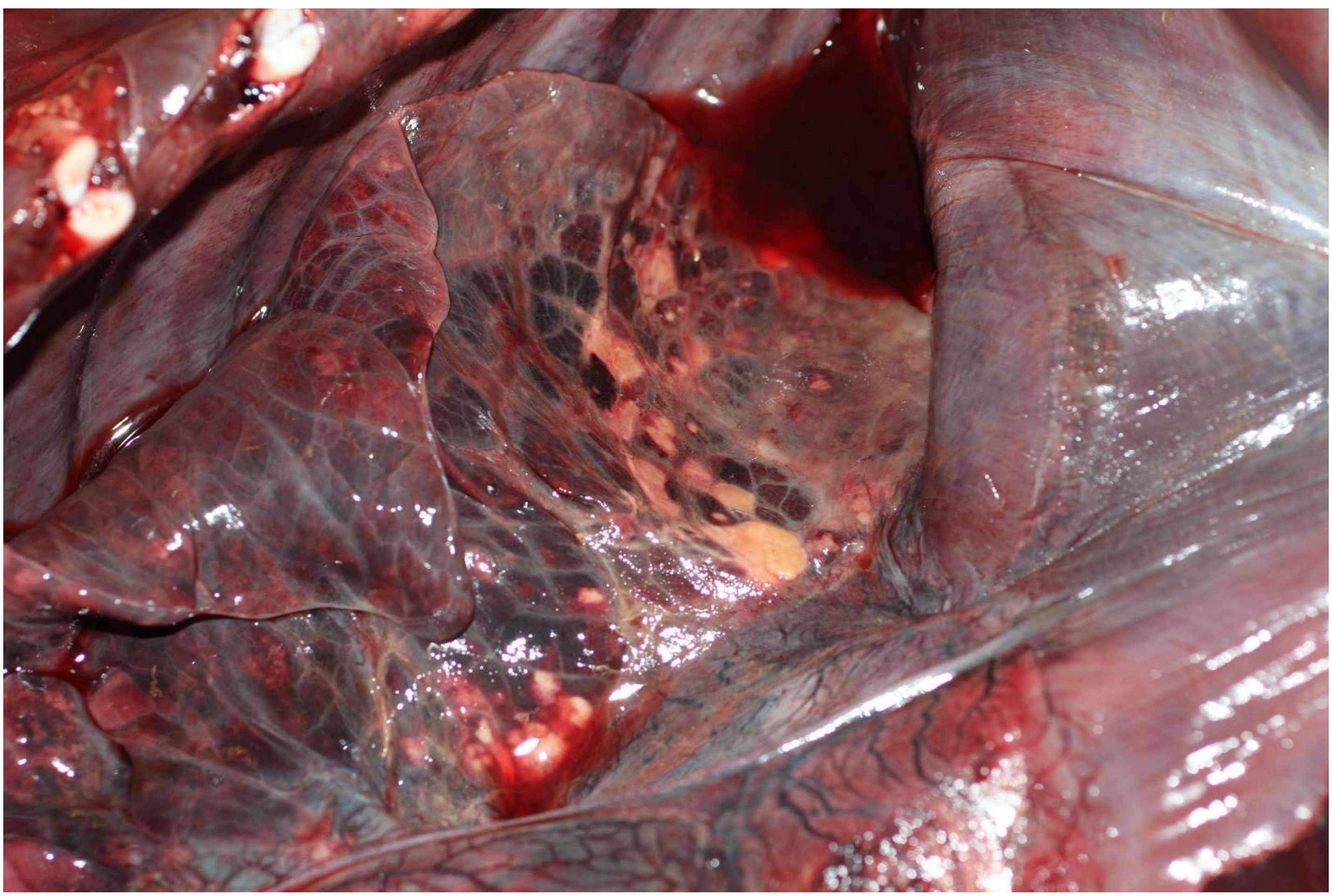
Marked diffuse vascular congestion, meninges (top) and brain (bottom)



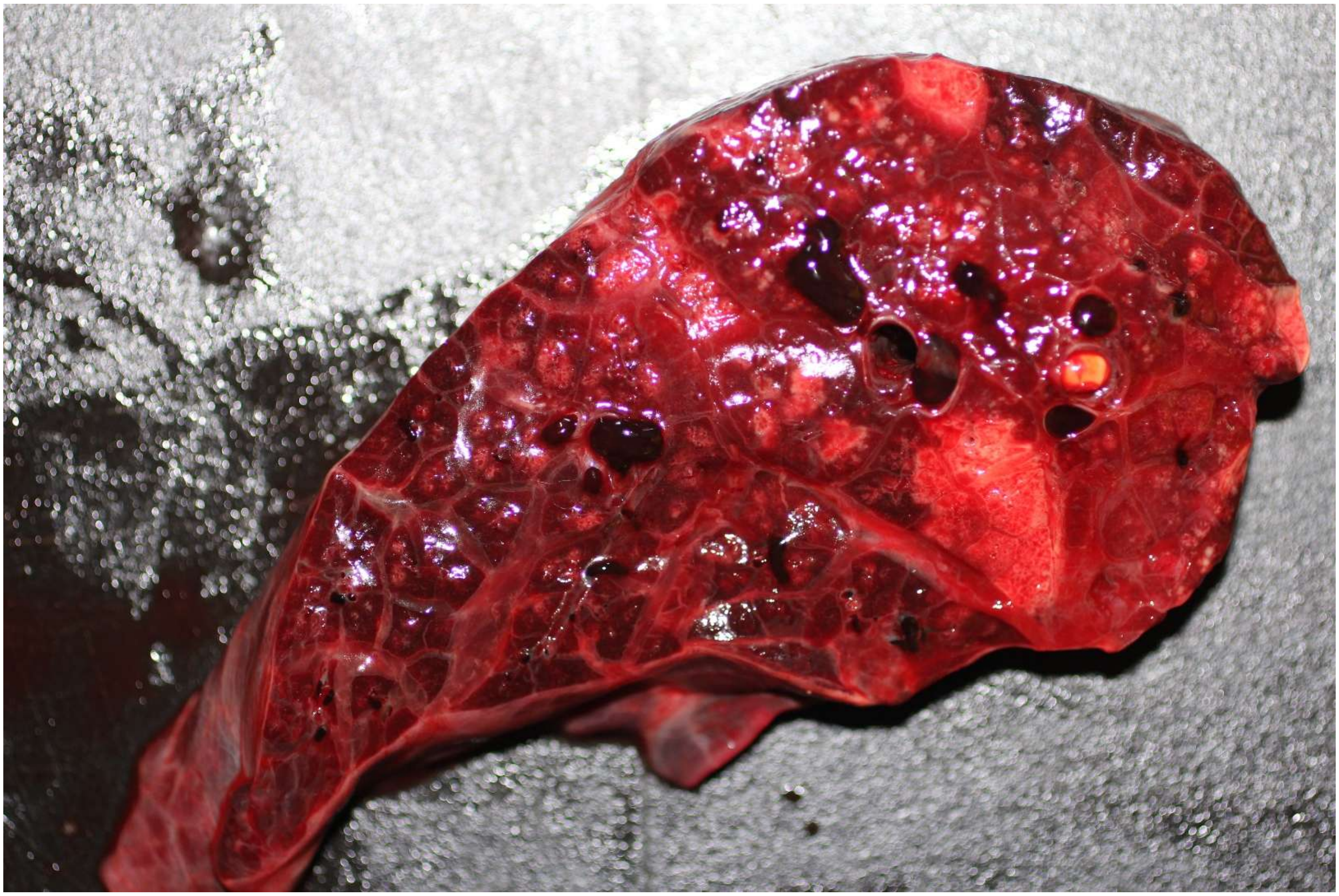


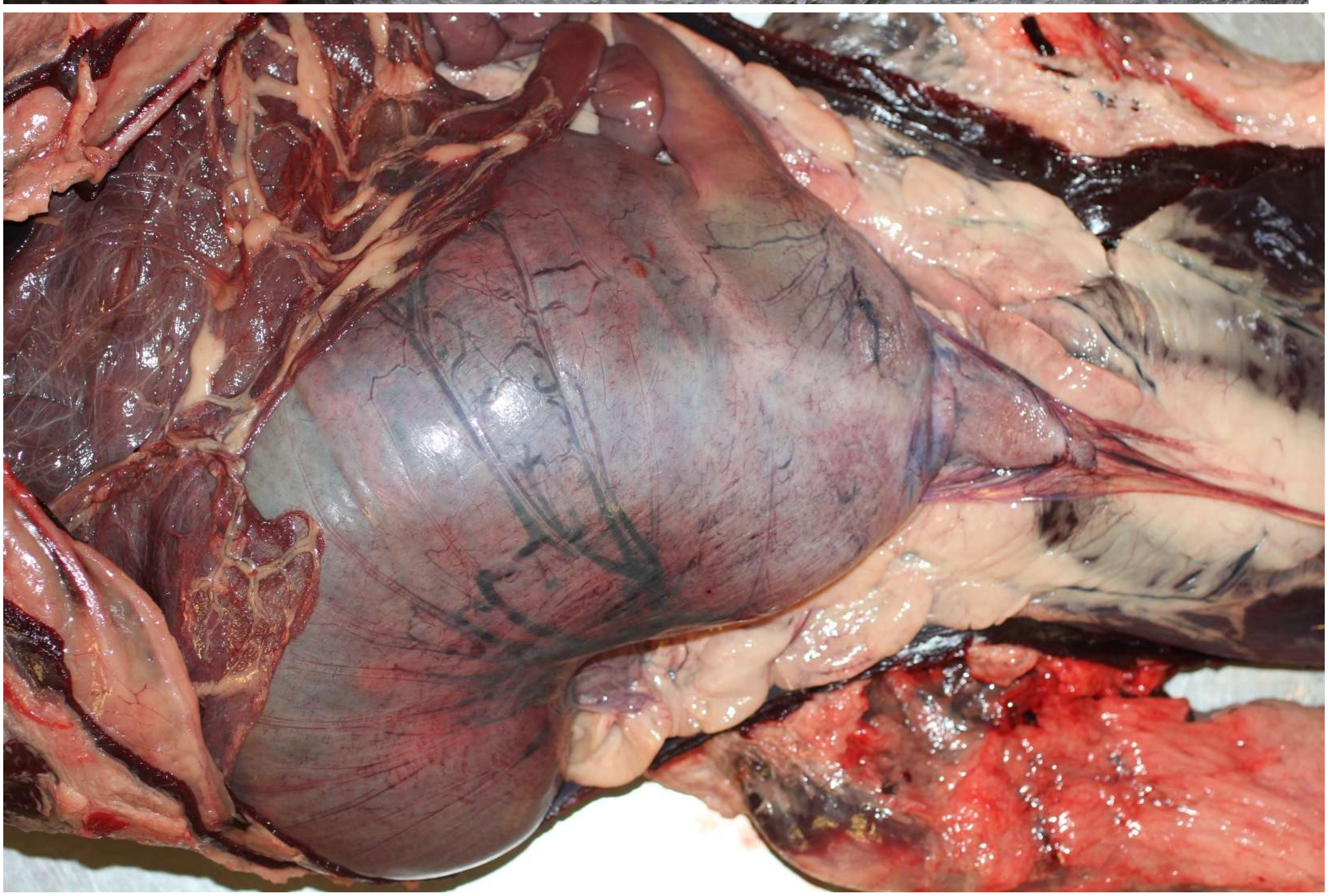
Pleural effusion (top) Brownish myocardium, prominent epicardial vessels & atrial dilation (bottom)



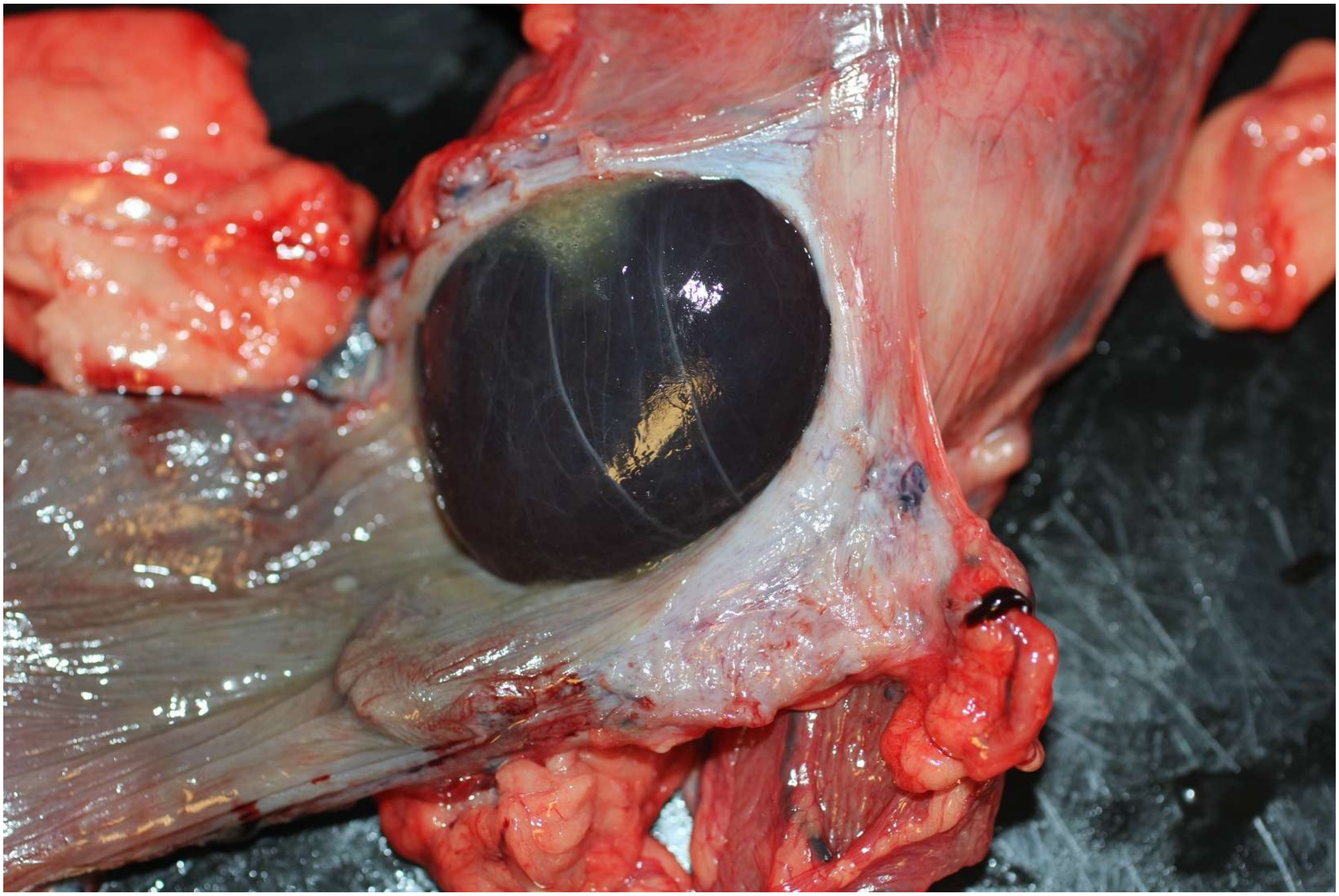


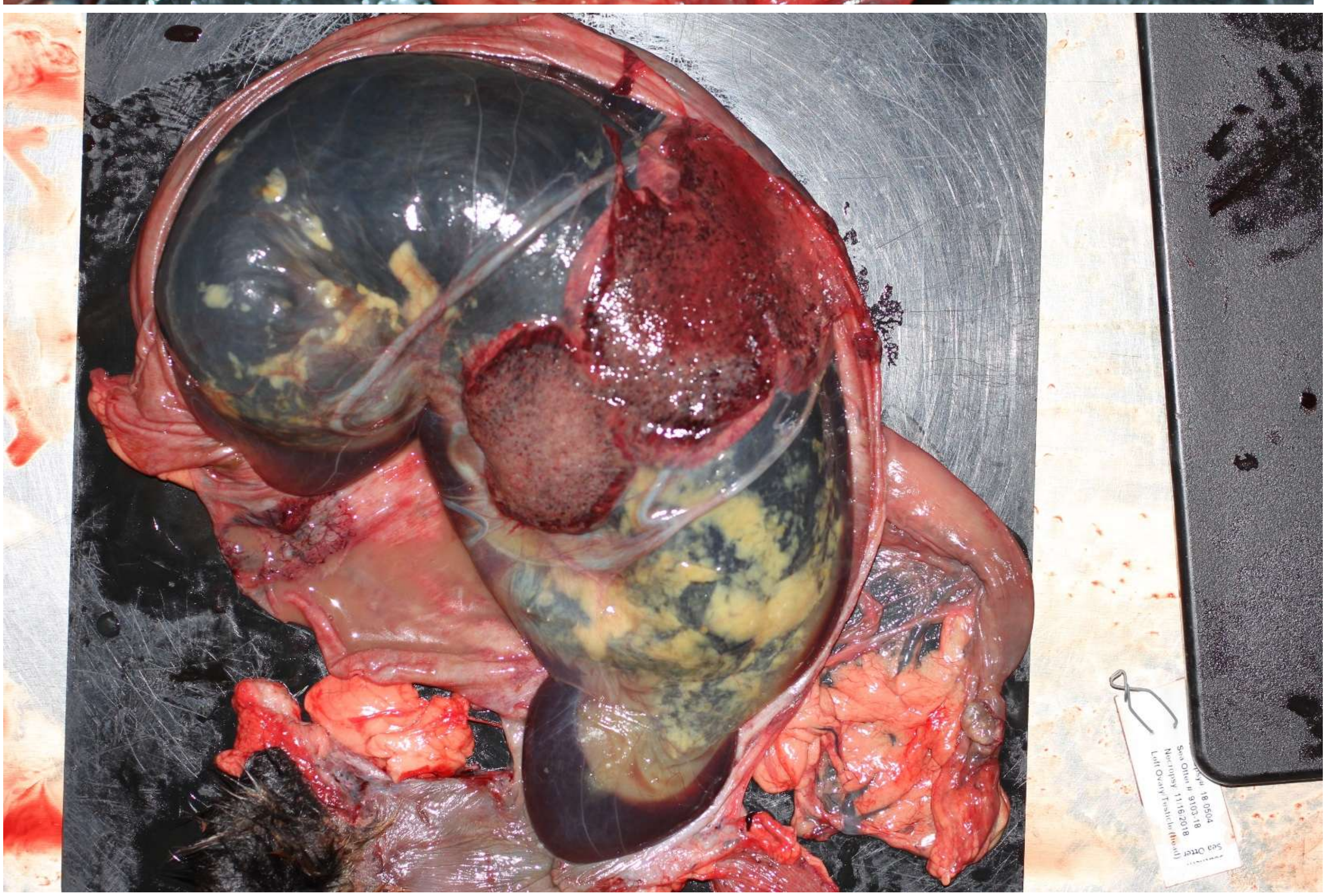
Brownish myocardium, atrial dilation (top)   Aspiration pneumonia, left caudal lung (bottom)



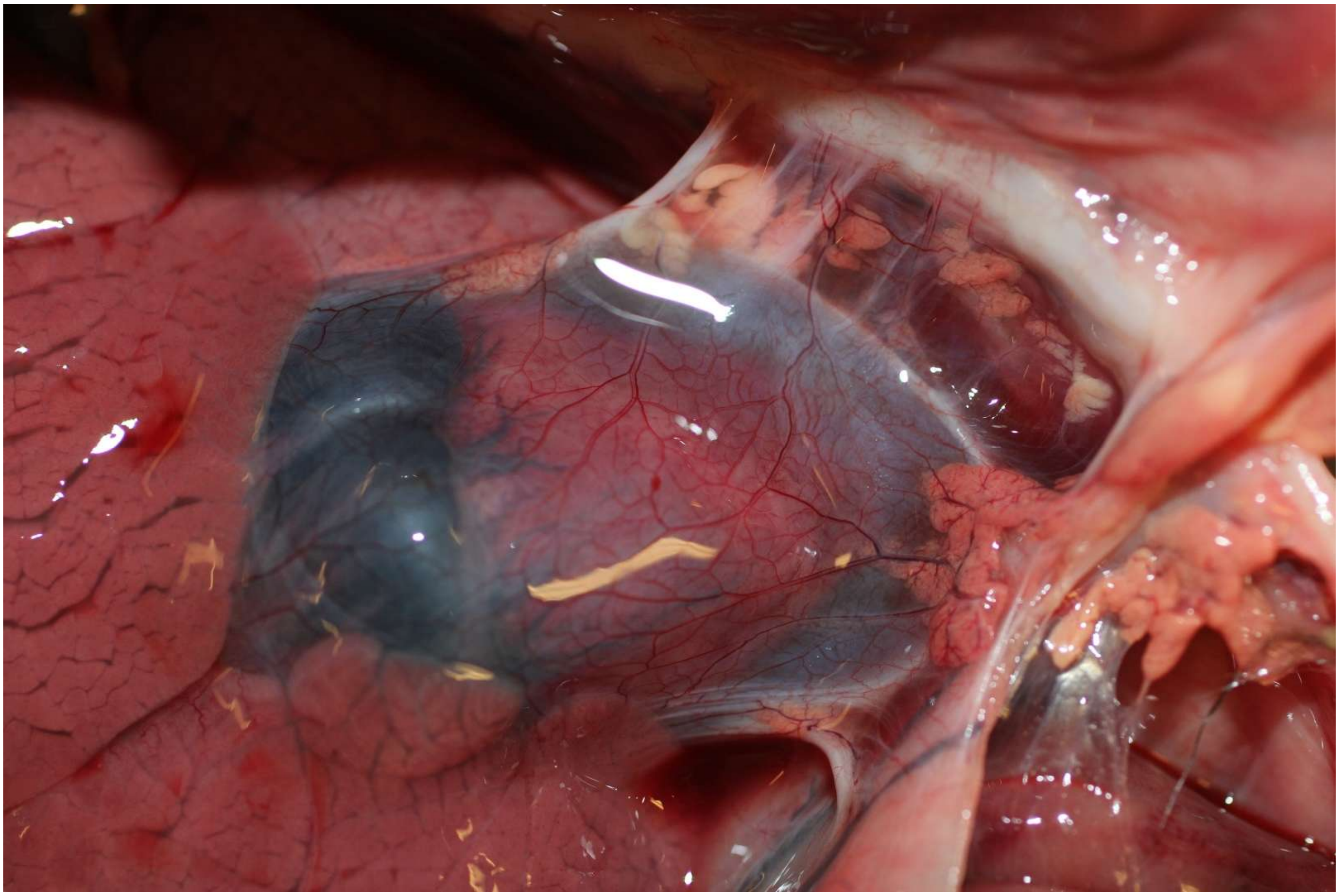


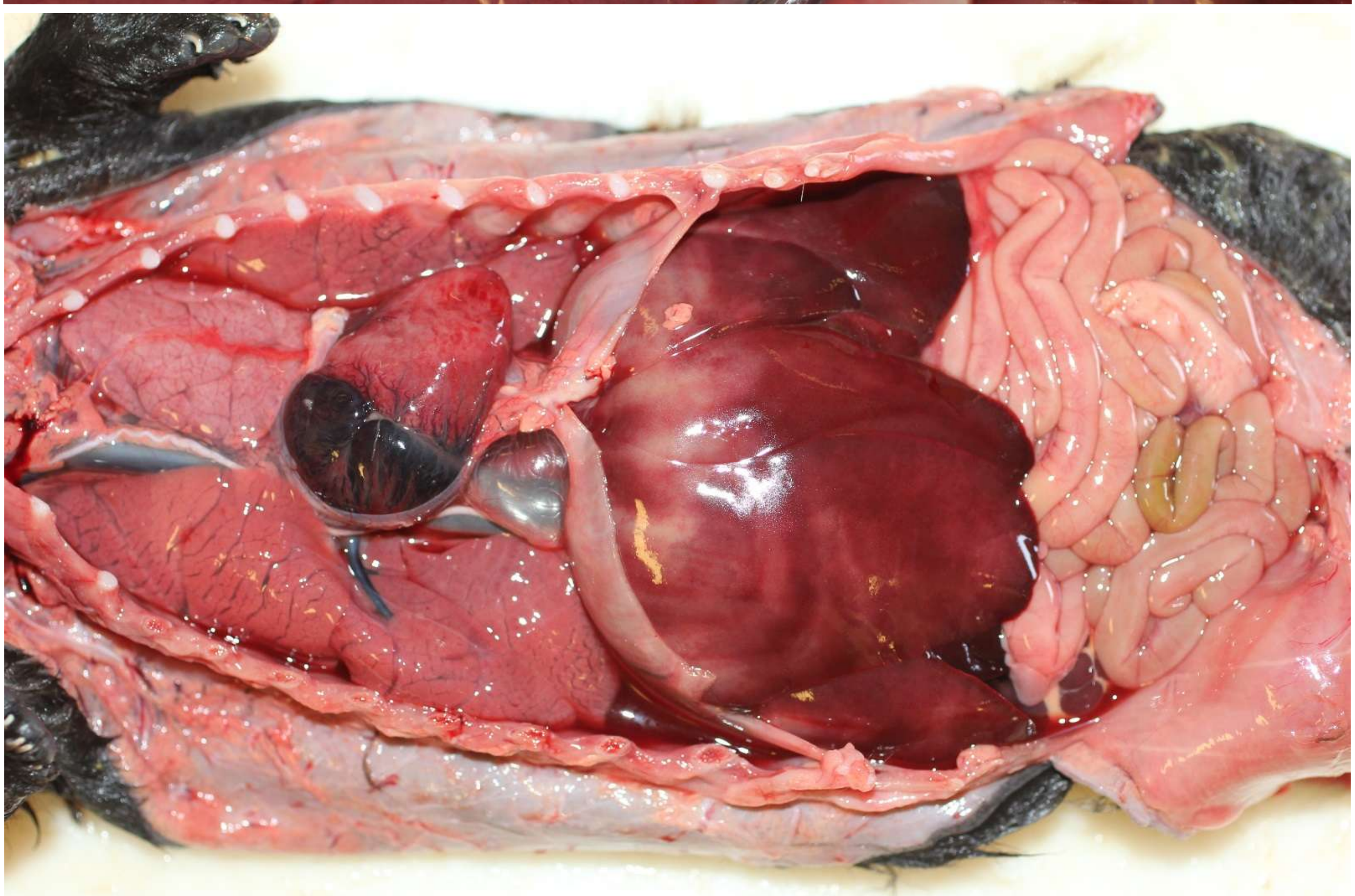
Aspiration pneumonia, left caudal lung (top)   Right horn pregnancy (bottom)



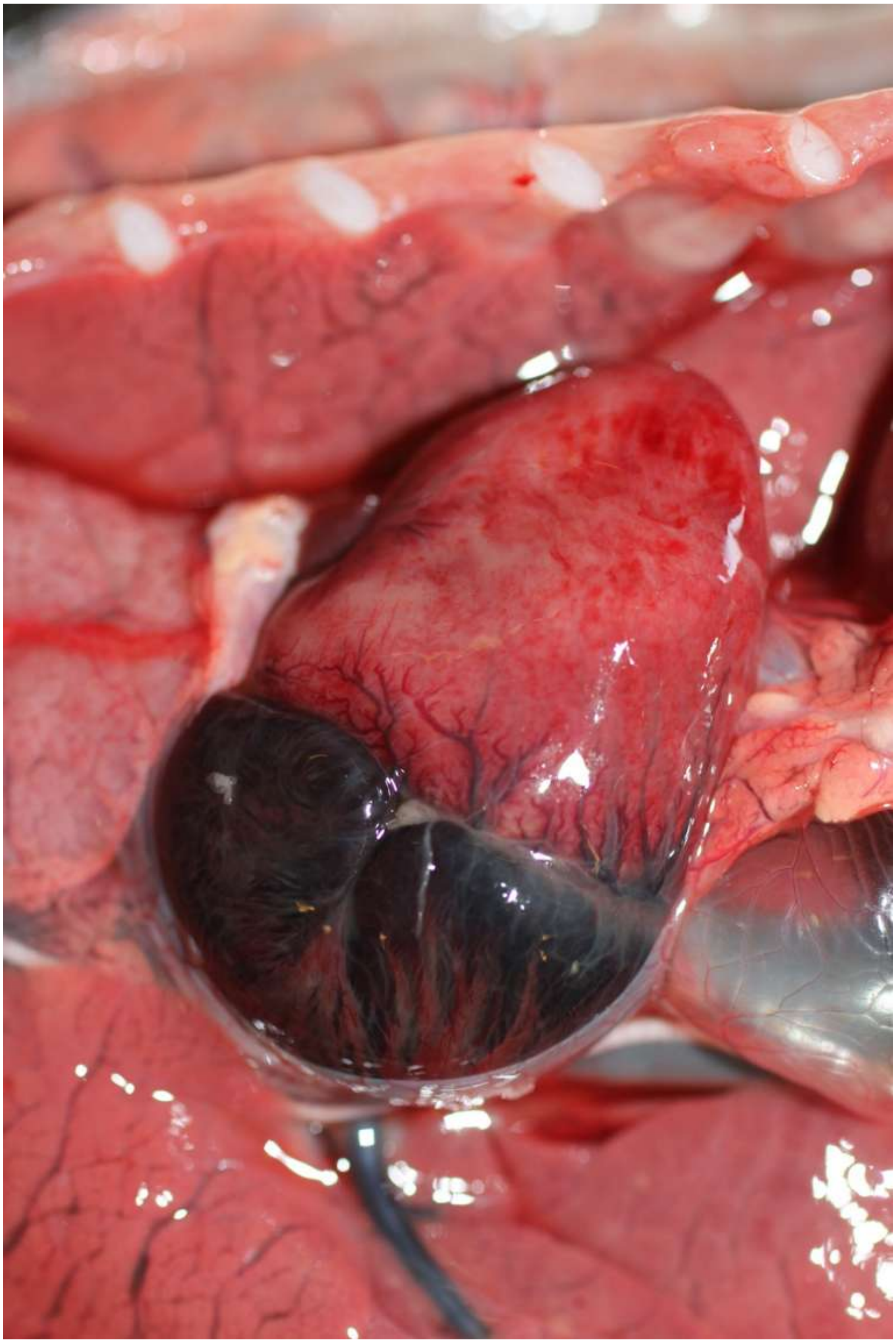


Fetal membranes in vaginal canal (abortion or pre-term birth) (top)
Severe fetal meconium smearing (fetal distress) (bottom)

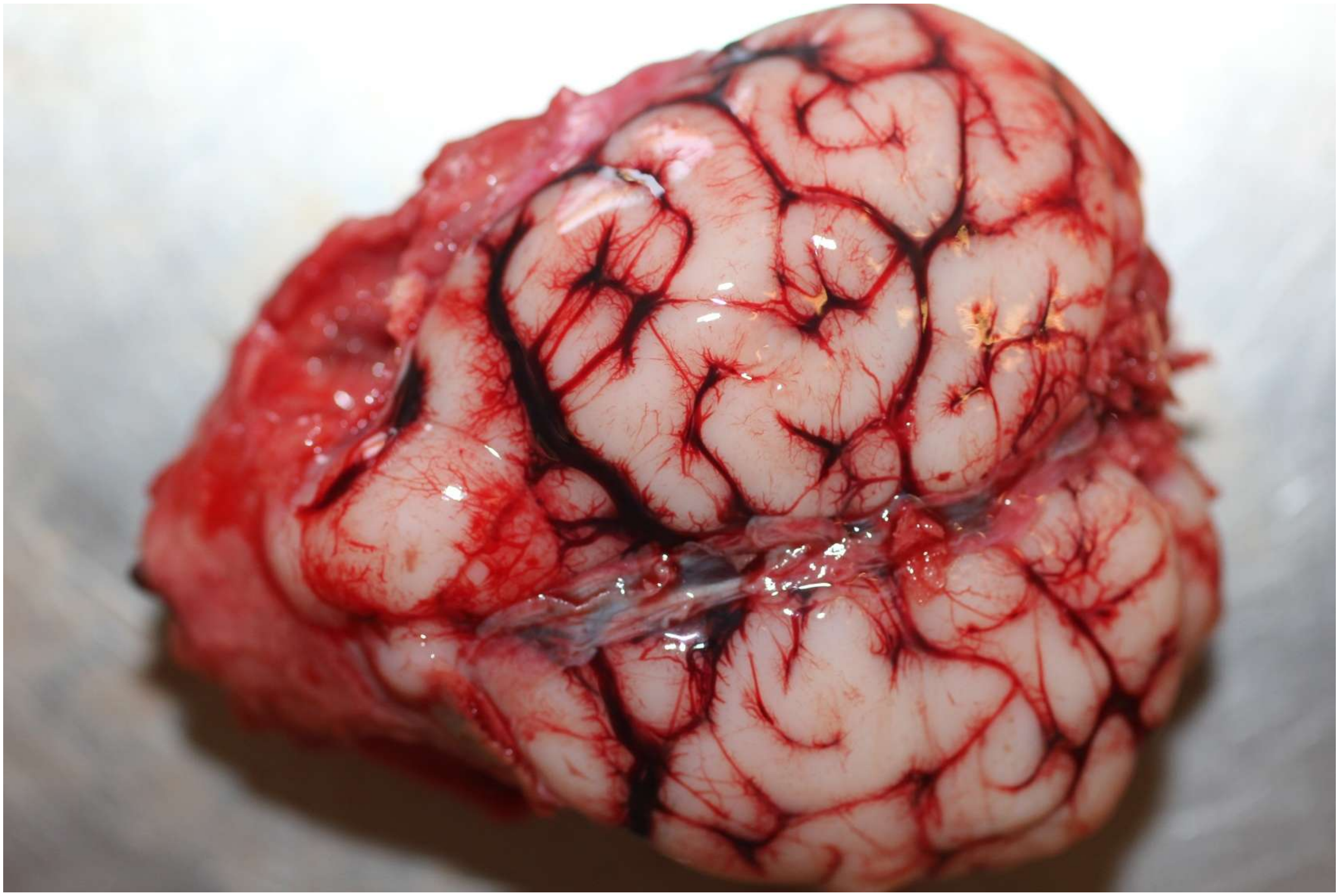




Fetus: Marked serous pericardial effusion (top)
Fetus: Myocardial congestion & possible epicardial hemorrhage (bottom)



Fetus: Myocardial congestion, atrial dilation & possible epicardial hemorrhage



Fetus: Marked vascular congestion, meninges

CDFW SEA OTTER NECROPSY REPORT

California Department of Fish and Wildlife
Office of Spill Prevention and Response
Marine Wildlife Veterinary Care and Research Center
151 McAllister Way
Santa Cruz, CA 95060
(831) 469-1719

Sea Otter:	9140-19
UCD PATH:	19S0010
MWVCRC Necropsy #	19-0006
Report Date:	1/18/2019
Report Status:	Gross

CASE PROFILE

DFG/BRD#:	1351	**Report By:**	Dr. Melissa Miller
UON#:	N-1627-16-S	**Necropsy By:**	Miller, Dodd, Batac, Young
MBA#:		**Necropsy Date**	1/7/2019
Date Found:	1/5/2019	**Condition:**	Fresh
Condition Found:	Fresh	**Sex:**	Female
Live Strand:	No	**Age Class:**	Adult
Euthanized:	No	**Estimated Age:**	9-10 yrs by M Miller
Date Died:		**Location:**	Monterey Harbor
Total Length (cm)	120.5	**County:**	Monterey
Weight (kg):	17.6	**ATOS:**	377B
Nutritional State:	Emaciated	**DSOFS COD:**	11
SQ Fat:	None	**Histopathology**	Full
Food in Gut:	Little		

MORTALITY DATABASE CODING

Primary COD : Cardiomyopathy

Sequela 1: L & R heart failure

Secondary COD: Poss ELS

Tertiary COD: Gastric erosions/melena

Quaternary COD: Poss SA/chronic DA intoxication.

CASE BACKGROUND

Teri Nicholson 05Jan2019:
Here is a fact sheet for the NSF study female I picked up today (05Jan2019). Her first capture was at Monterey Bay Inn on 6/2/2016 (tagged, radio transmitter freq. 166.380 and TDR implant), and her second was in Monterey harbor on 10/18/2018 (retag and TDR removal). During this time she has successfully reared 3 pups. She weaned her last pup (1390-18) in early November 2018. The pup was approximately 22 weeks old.

Her primary range was from Monterey Bay Inn to Wharf 2, but trackers have resighted 6380 as far down coast as Hopkins Marine Station. During the past couple years she has been observed foraging primarily on mussels and crabs, but spotters have also occasionally recorded her eating urchins, worms, sand dollars, and abalone. Yesterday (04Jan2019), an observer (PC) saw her foraging on crab near the coastguard pier.

Within the last week or so, MBA has received calls reporting her as hauled out on the docks near the coast guard boat slips in Monterey harbor. She has been known to haul-out in this area, but usually under not on the docks. When MBA staff responded to these reports, her overall appearance, condition, and location did not seem to warrant capture. Karl Mayer responded to another call from the public on Wednesday, but he found her in the water, wrapped in kelp and difficult to assess. He may be able to provide you with more details if needed.

GROSS DIAGNOSES

1.) Cardiomyopathy, subacute/chronic, char. by:
-Mild myocardial mottling (PHOTO)
-Possible mild cardiac dilation and mild reverse D-shaped heart (PHOTO)
-Pale, opaque left atrial wall (PHOTO)
-Severe pericardial effusion (10 ml)

1a.) Left and right heart failure, subacute/chronic
-Marked diffuse hepatomegaly (2x normal size) & congestion (PHOTO)
-Marked serous peritoneal effusion (Aerobic culture pending) (PHOTO)
-Marked dilation and fluid-distension of peritoneal lymphatics (PHOTO)
-Marked perihilar edema, hilar lymphadenopathy & peri-hilar septal pulmonary fibrosis, with moderate septal edema of more distant lung fields (PHOTO)
-Marked multi-organ congestion (PHOTO)
-Mild serous pleural effusion
-Moderate diffuse venous dilation
-Mild pleural venous shunting
-Marked pericardial effusion (10 ml)
-Moderate red-tinged foamy fluid in airways (PHOTO)

2.) Possible end-lactation syndrome
-Stage 5 female
-Severe emaciation (No adipose, marked diffuse muscle atrophy) (PHOTO)
-Subacute nose wound (large pink/white) (PHOTO)
-Mammary tissue visible but not lactating (trace mild in teat sinus) (PHOTO)
-Ovaries: 5 CAs, one possible late follicle/early CL left ovary, & possible focal mild post-ovulatory hemorrhage right ovary (PHOTO)
-Placental scars left & right uterine horn (PHOTO)
-Coat mildly dry/coarse

3.) Gastric erosions and melena, severe

4.) Brain diffusely light tan, but not enlarged, herniated or congested (R/O SA/chronic DA damage in CNS on histopathology) (PHOTO)

5.) Mild multifocal post-surgical complications:
-Focal mild incision abscess/focal dehiscence with exterior draining tract, caudal end of most recent ventral midline surgical wound, with mild secondary perilesional matting of pelage due to proteinacious fluid leakage (Aerobic/anerobic culture pending for incision and right inguinal LN-PHOTO)
-Mild edema of peri-surgical subcutis (PHOTO)
-Ventral surface of abdominal wall linea closure is slightly bunched, with approx. 3 mm, minimally-degraded end of suture material protruding through ventral midline closure of linea alba into peritoneal cavity (PHOTO)
-Ventral omentum near greater curvature of stomach: Focal firm mass of necrotic tissue (omentum +/- omental adipose, pres. pending histopathology) associated with focal stellate pattern of tissue bunching, with multifocal perforation of the ventral leaf of the omentum (Possible instrument removal site?) (Histology pending-PHOTO)
-VHF transmitter entrapped in omental bursa, instrument located at outer edge of bursa, very loosely fixed, mildly boloed/twisted (~360 degrees) and loosely wrapped around several loops of intestine (affected intestine appeared WNL and viable at the time of death (PHOTO)

-Hx possible partial TDR extrusion from falciform ligament into the peritoneum, per 10/18 surgical notes

INCIDENTAL:

1.) Possible discrete branchial cleft cyst (congenital remnant of gill) on outer wall of thoracic esophagus (Histology pending-PHOTO)

2.) Mild intestinal Corynosoma

3.) Teeth fair condition (PHOTO)

4.) Mild nasopharyngeal acariasis (~10 adults/cigars only) with associated mild/moderate catarrhal exudate

5.) Multifocal white pulmonary pleural spots (Same as #3 [mites] or related to cardiac failure? (Histopathology pending)

6.) Mild mitral valve endocardiosis (PHOTO)

7.) Left 12th rib at costochondral junction: Focal cartilaginous proliferation

8.) Mild dehydration

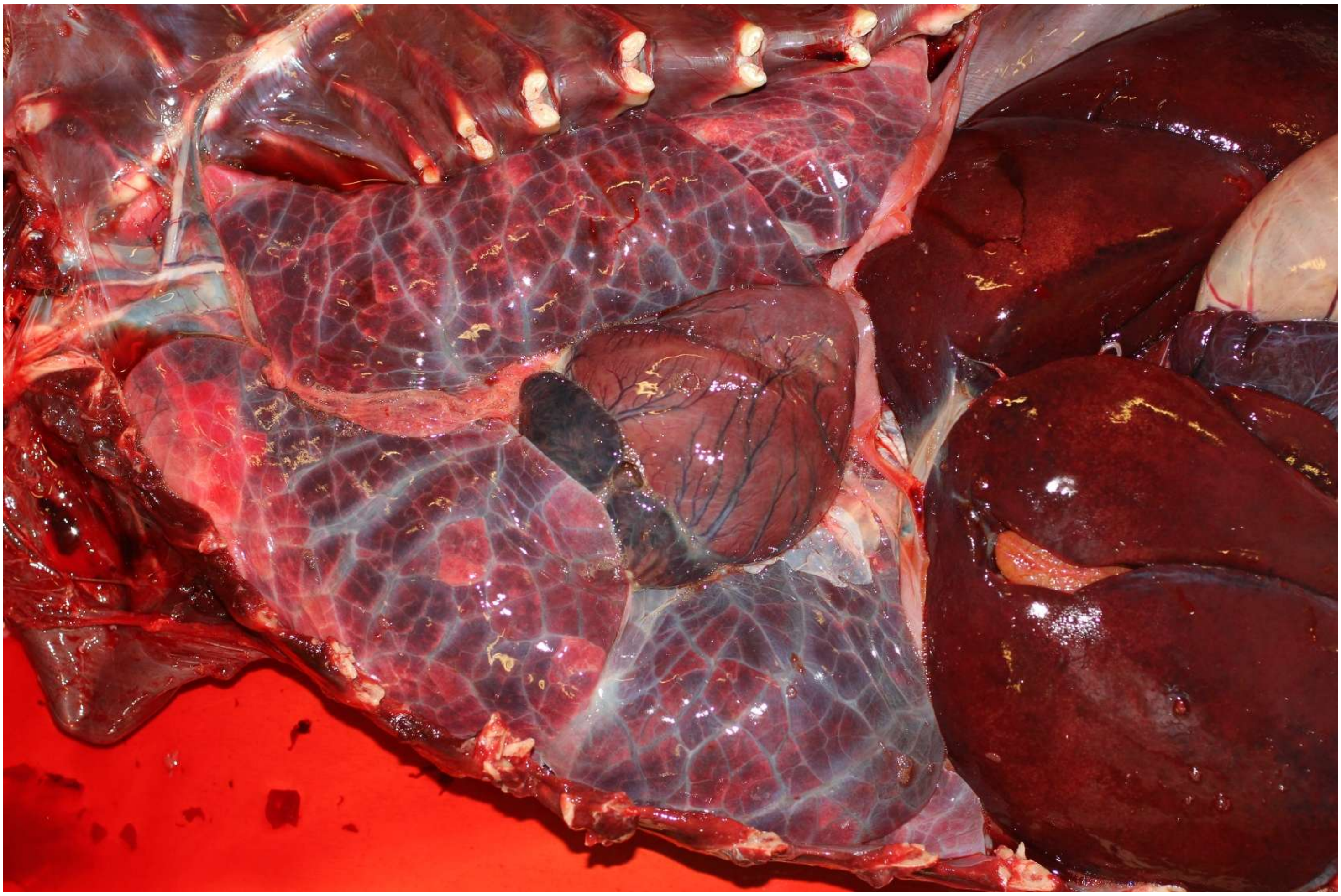
GROSS SUMMARY

Pending results of bacterial culture and histopathology, the primary cause of death was biventricular heart failure secondary to SA/chronic cardiomyopathy. ELS may also have been a contributing factor. Gastric erosions and melena are considered significant peri-terminal lesions. Based on the diffuse, mild tan discoloration of neuropil, brain histopathology may reveal lesions suggestive of prior domoic-acid-associated lesions, or other brain pathology.

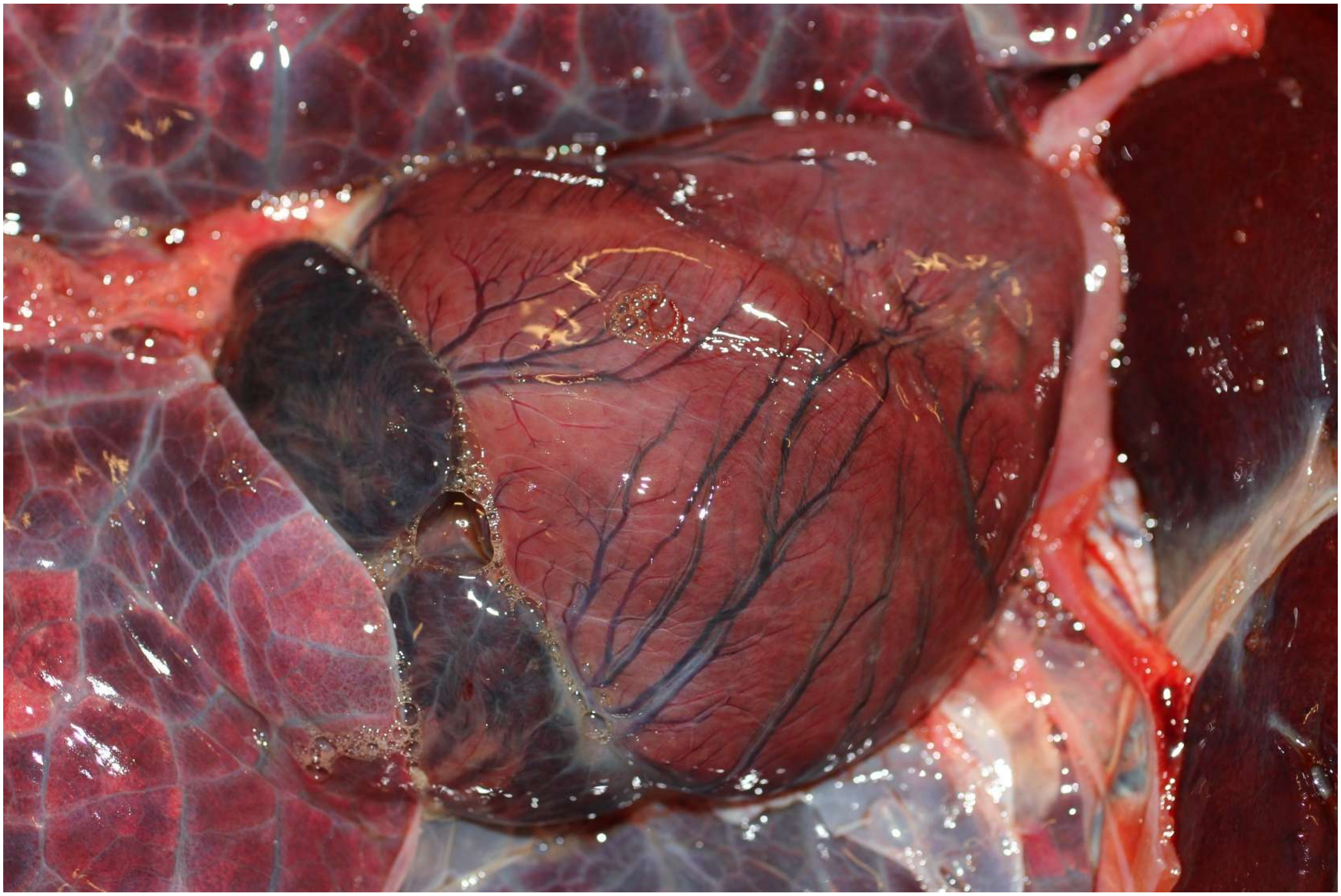
The surgery-associated lesions were concerning, but were considered mild in this case, pending results of bacterial culture and histopathology. Pending discussion with the surgical team and microscopic examination, the focal omental mass and associated omental holes could be a site of previous surgical removal of an instrument from the omentum. However, per the clinical history, TDR placement in this animal was in the falciform ligament, so this finding is a bit unexpected.

Completed:
Gross necropsy
Gross photos

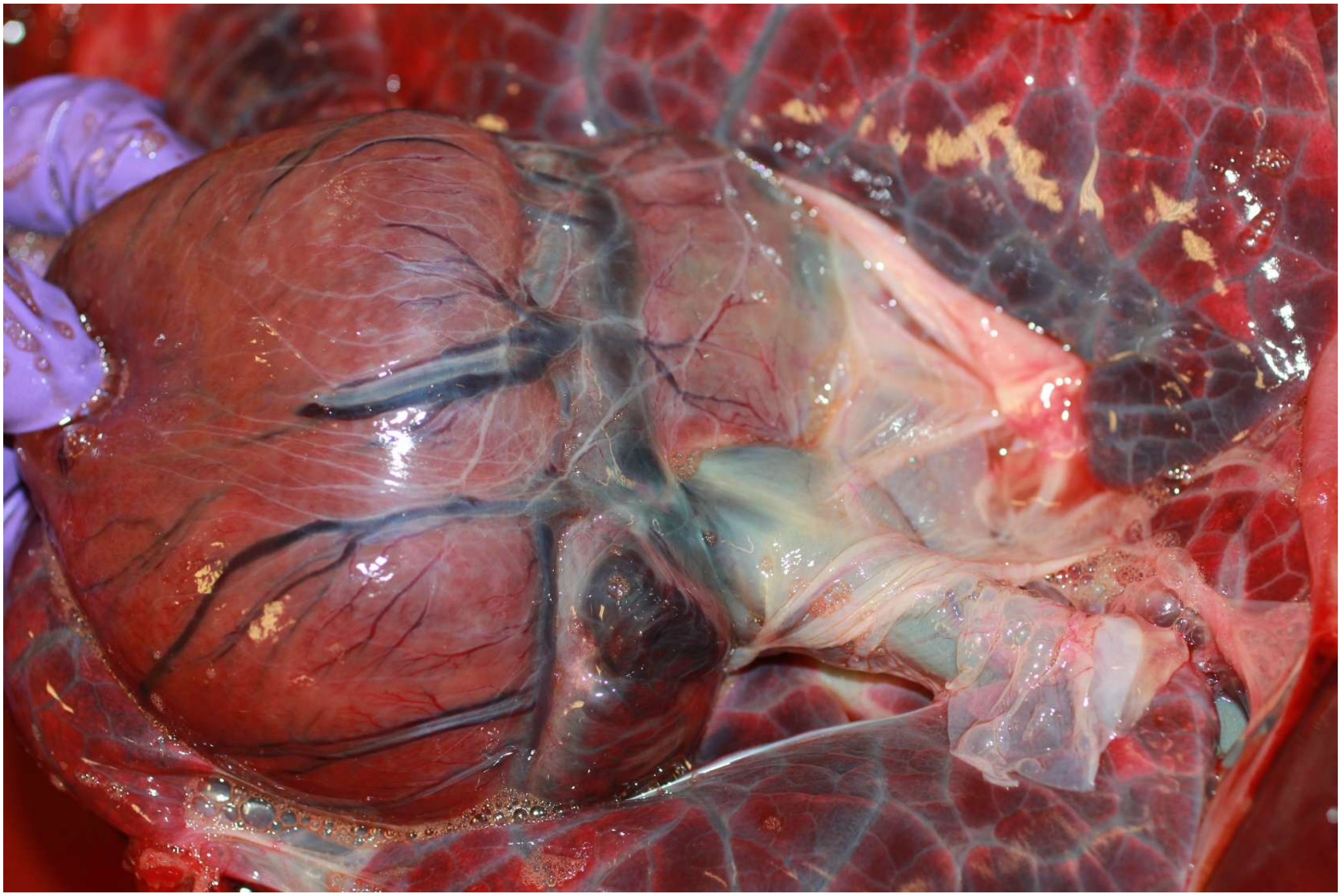
Pending:
Bacterial culture (Ventral midline draining tract at Sx site, R inguinal LN, peritoneal fluid)
Histopathology



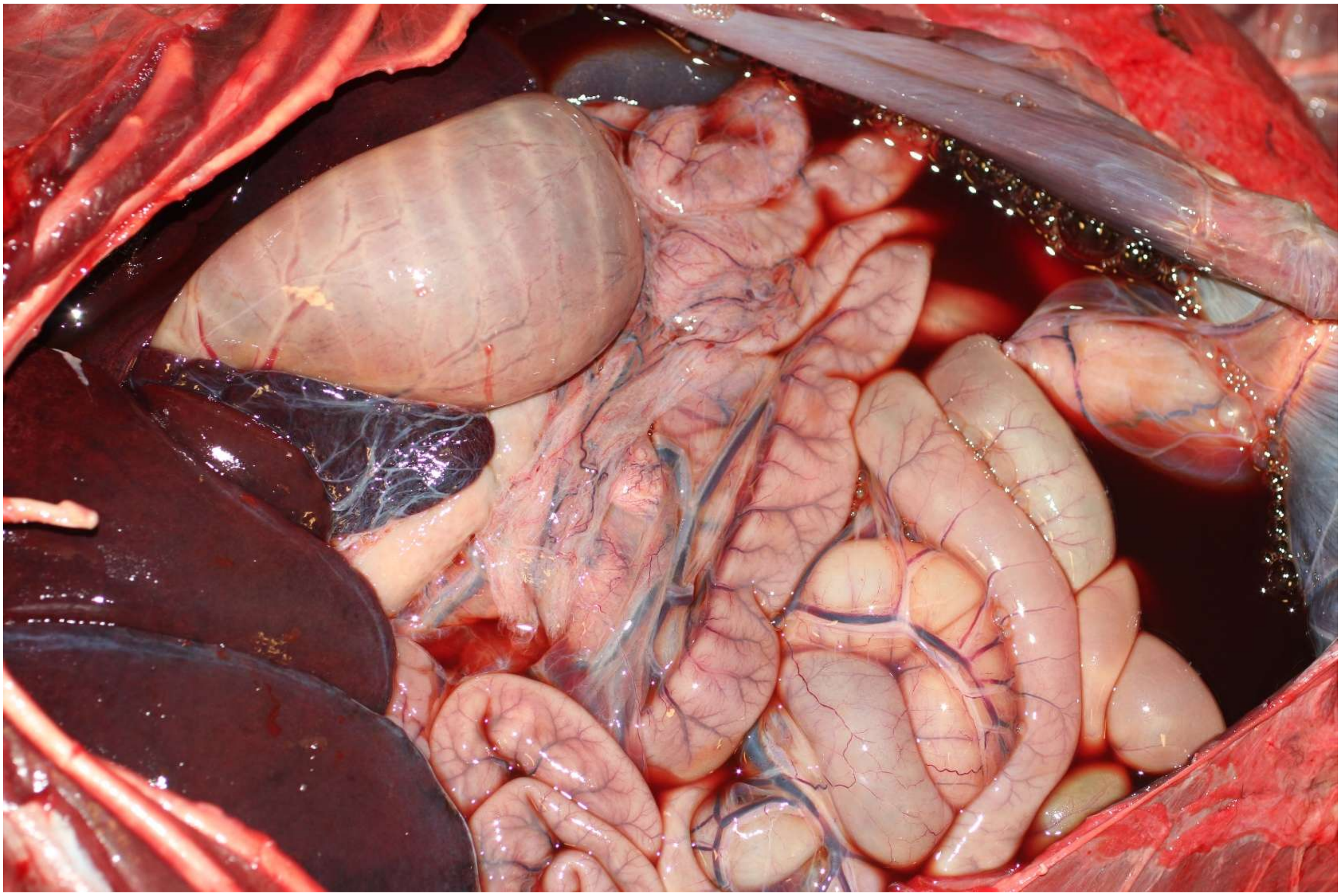
Mildly enlarged, reverse D-shaped heart, hepatomegaly & congestion & pulmonary septal fibrosis (cardiomyopathy with secondary left & right heart failure)



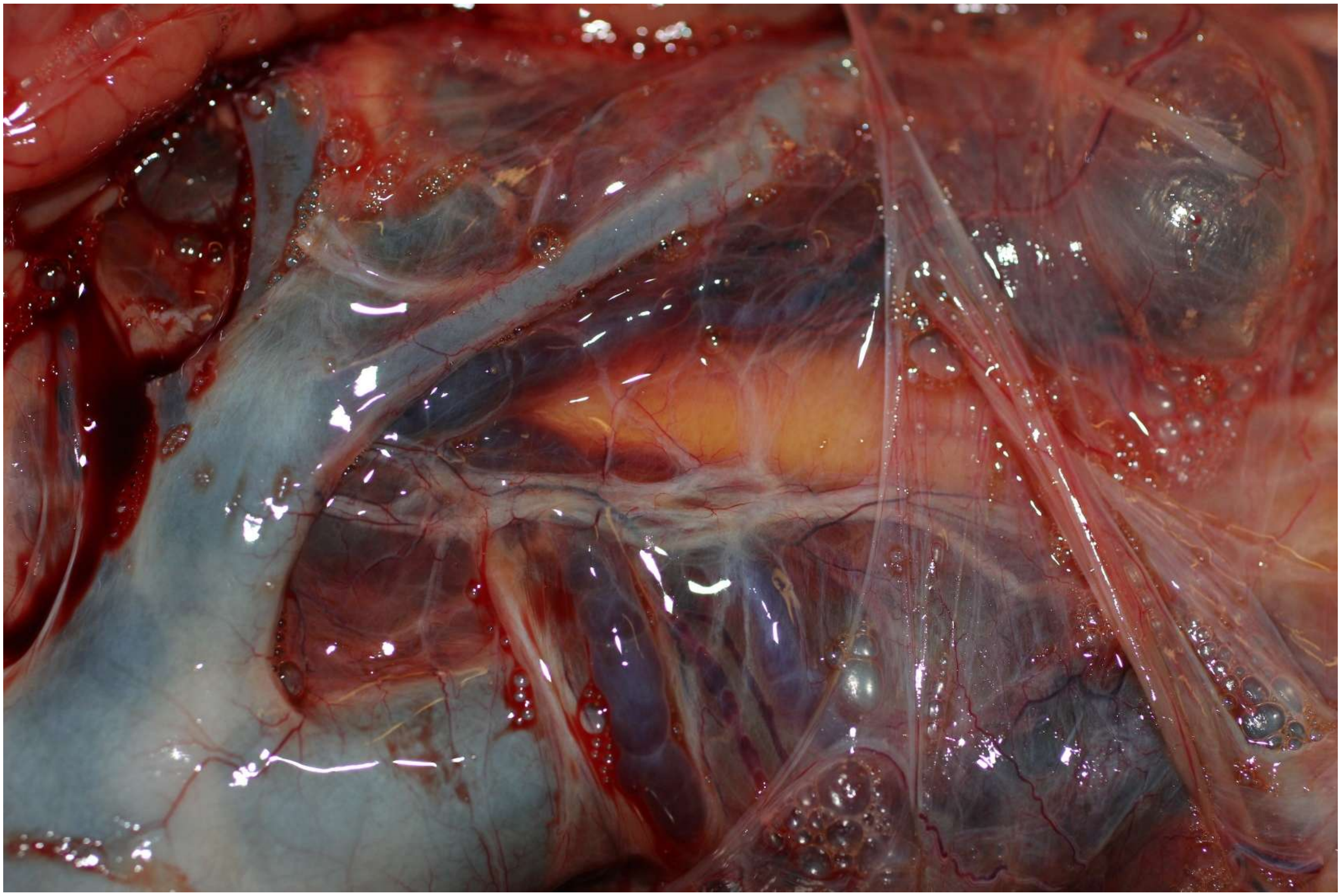
Closer view of ventral cardiac surface, showing reverse D-shape of heart (when viewed from above, indicative of right-sided cardiac dilation), & diffuse myocardial pallor & mottling (cardiomyopathy)



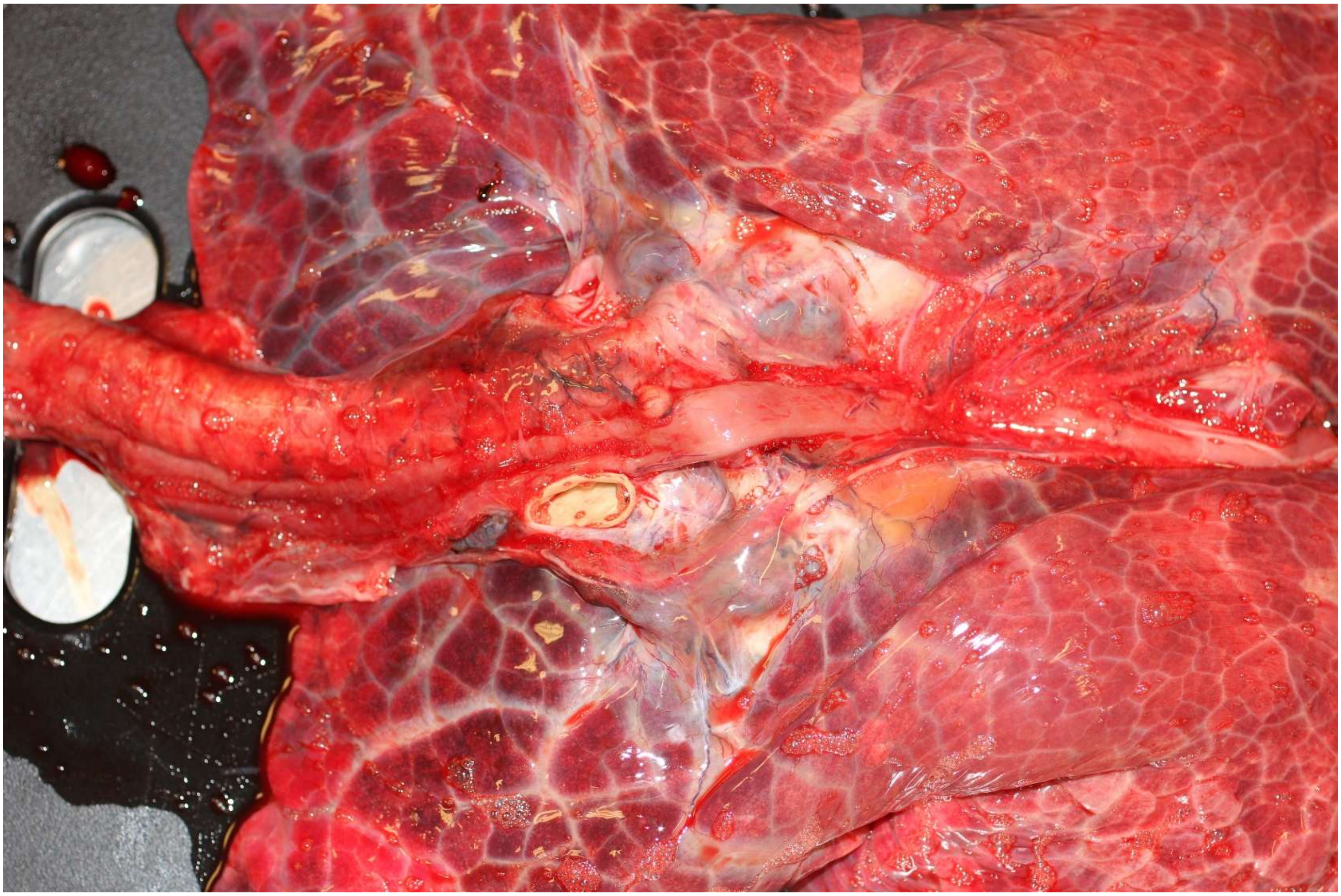
View of dorsal cardiac surface, showing myocardial mottling/pallor, dilation of coronary veins and pale to translucent left atrial wall



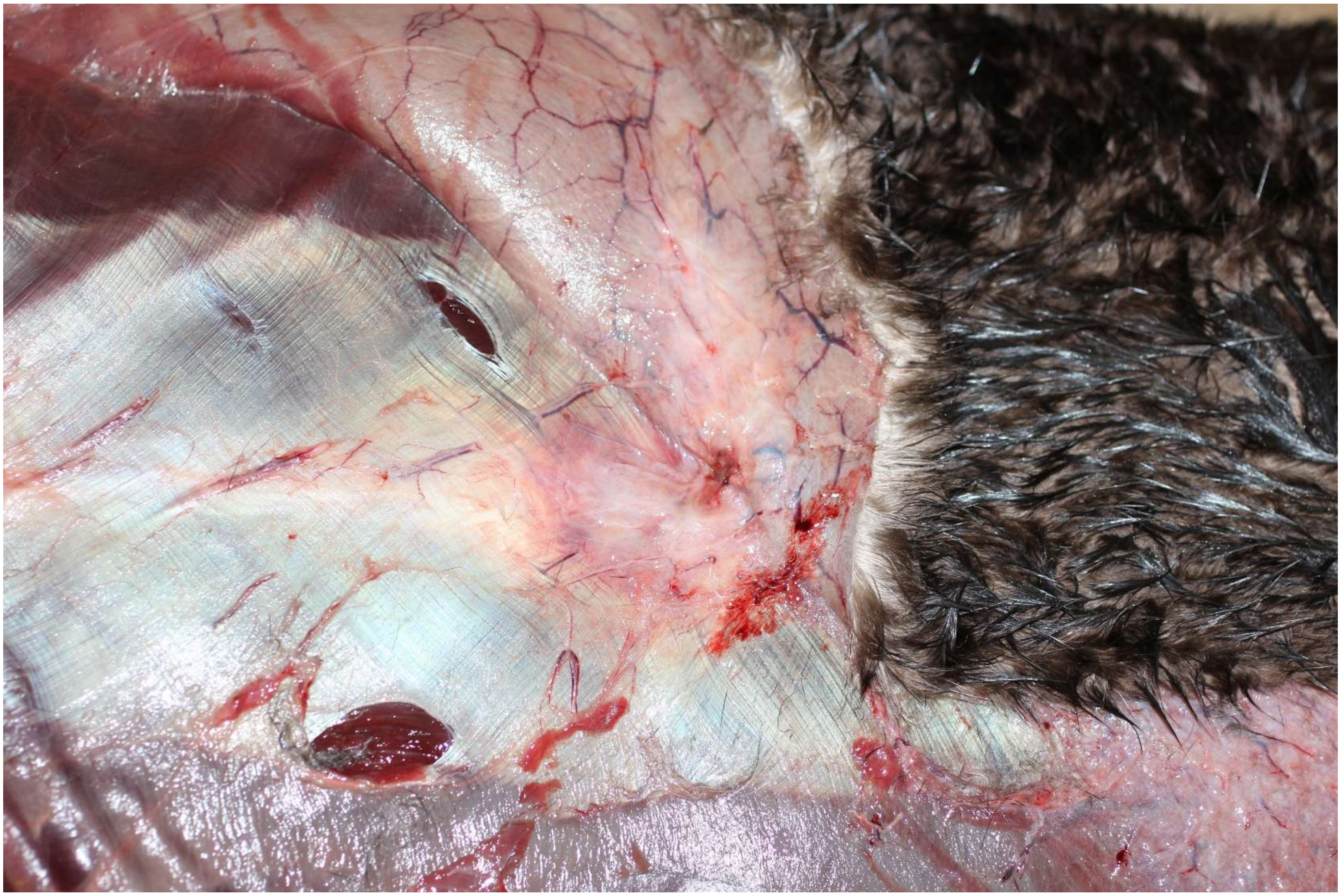
Marked hepatomegaly & congestion, and marked serous peritoneal effusion
(right heart failure)



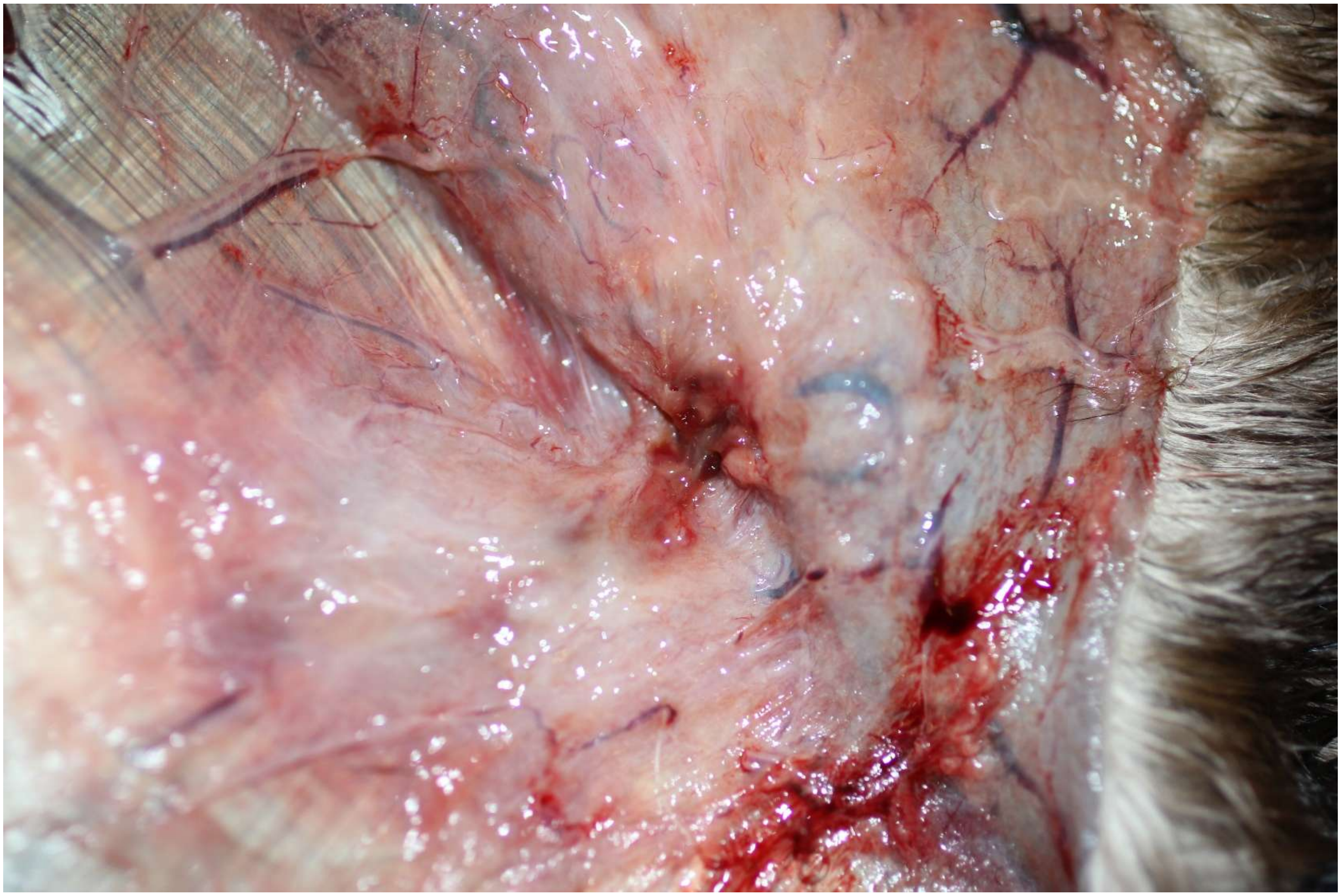
Faschial edema & marked fluid distension of peritoneal lymphatics (three light purple, linear, jointed-looking structures in image center) secondary to right heart failure



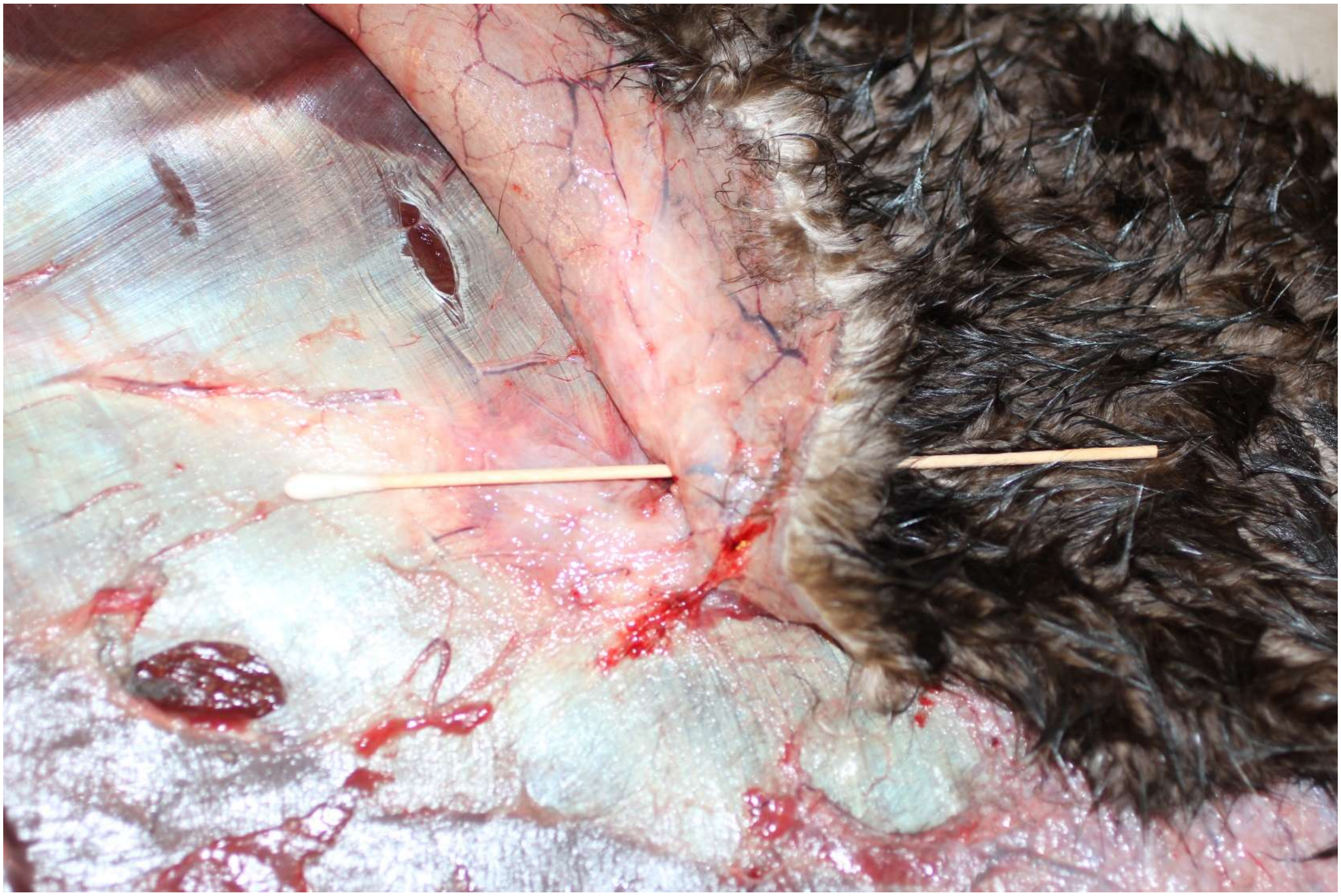
View of hilus (area where the trachea bifurcates and the main bronchi enter the lungs) and the cranioventral lung fields: There is marked perihilar edema, severe hilar lymphadenopathy due to chronic edema, & striking perihilar pulmonary septal fibrosis (chronic left heart failure). The pulmonary septal fibrosis is a tissue response to chronic edema in this region.



There is mild tissue edema at the site of the most recent ventral midline laparotomy. A small area of reddish discoloration is apparent at the caudal edge of the surgical site.

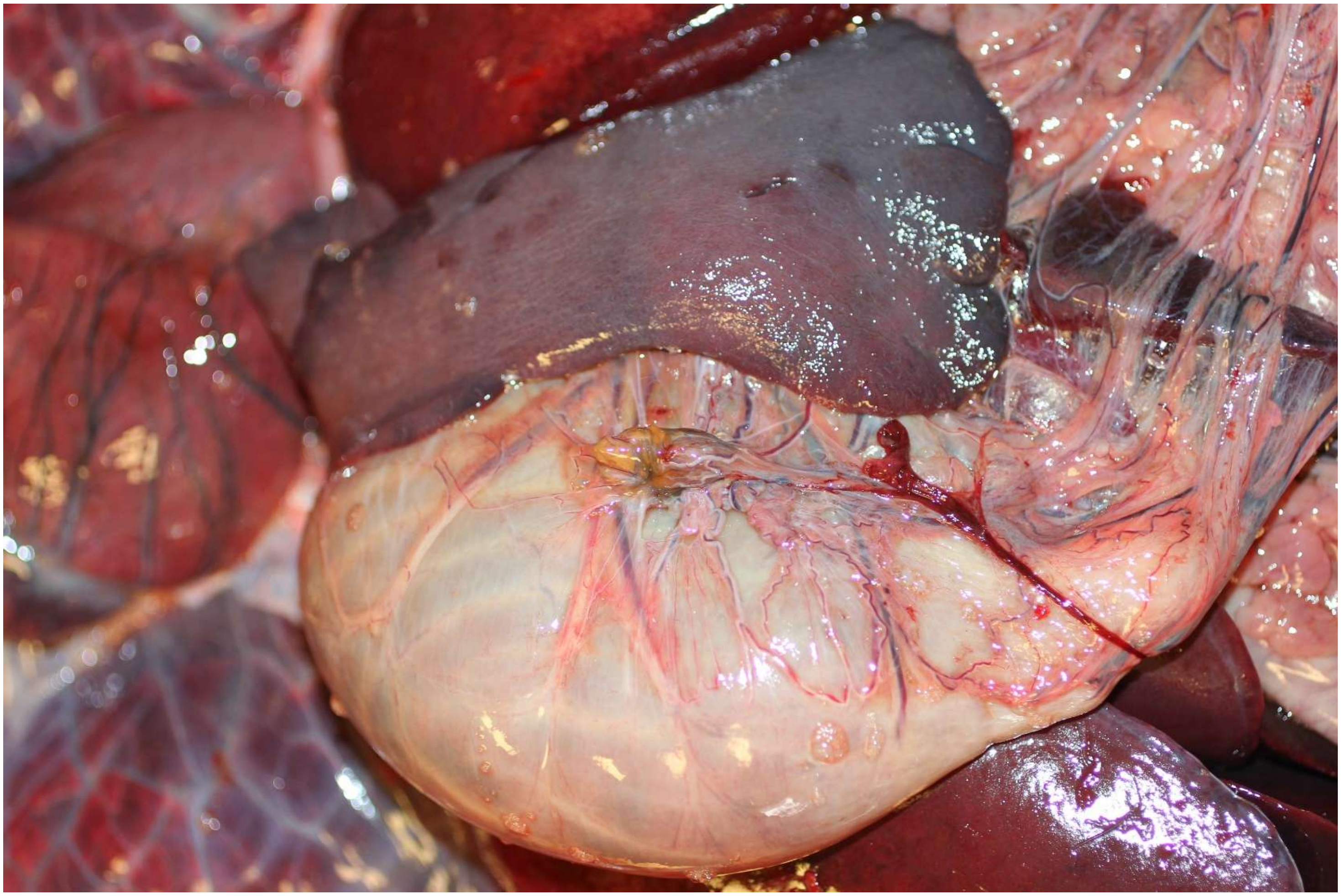


Closer view of the area of tissue discoloration at the caudal aspect of the surgical site. Scant pus and hemorrhage are associated with a small defect in the overlying integument.



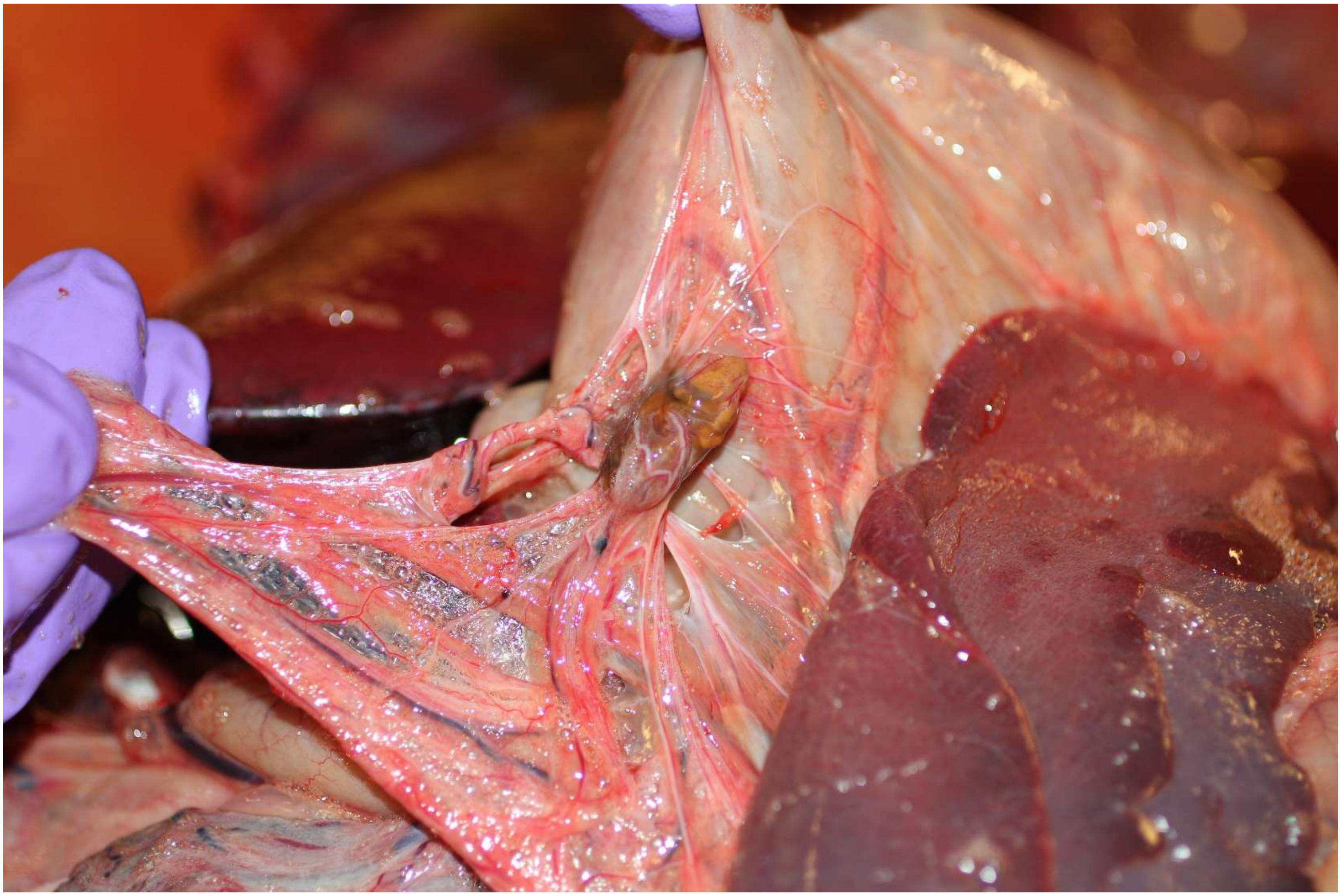
A probe inserted into the integument confirms that the defect shown in the previous photo is patent to the skin surface.

View of the same hole from the skin surface. There is mild matting of the adjacent pelage due to proteinacious fluid drainage from this lesion.

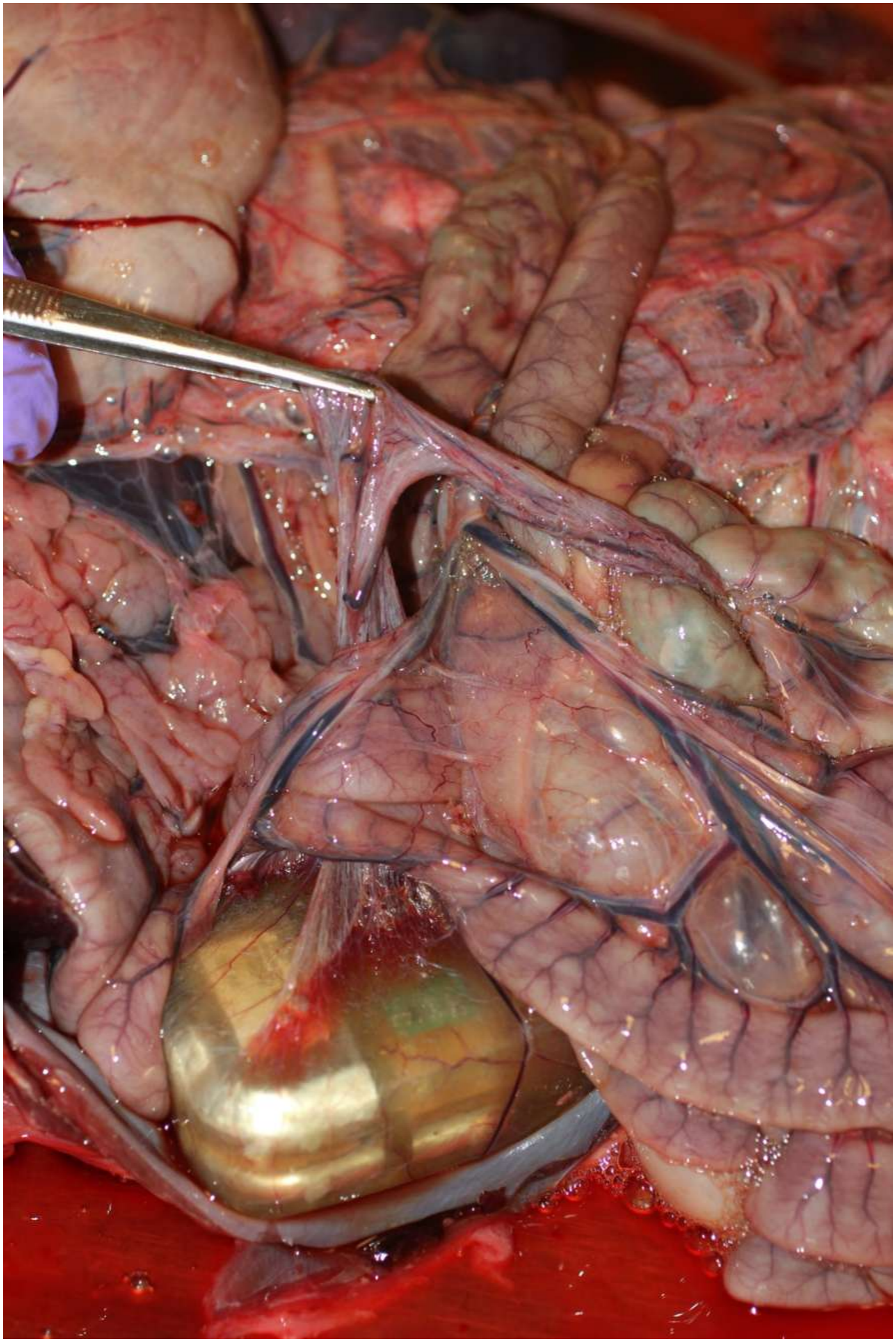


A small, firm, pale yellow mass was located at the center of a region of omental bunching, located in the ventral wall of the omental bursa near the greater curvature of the stomach

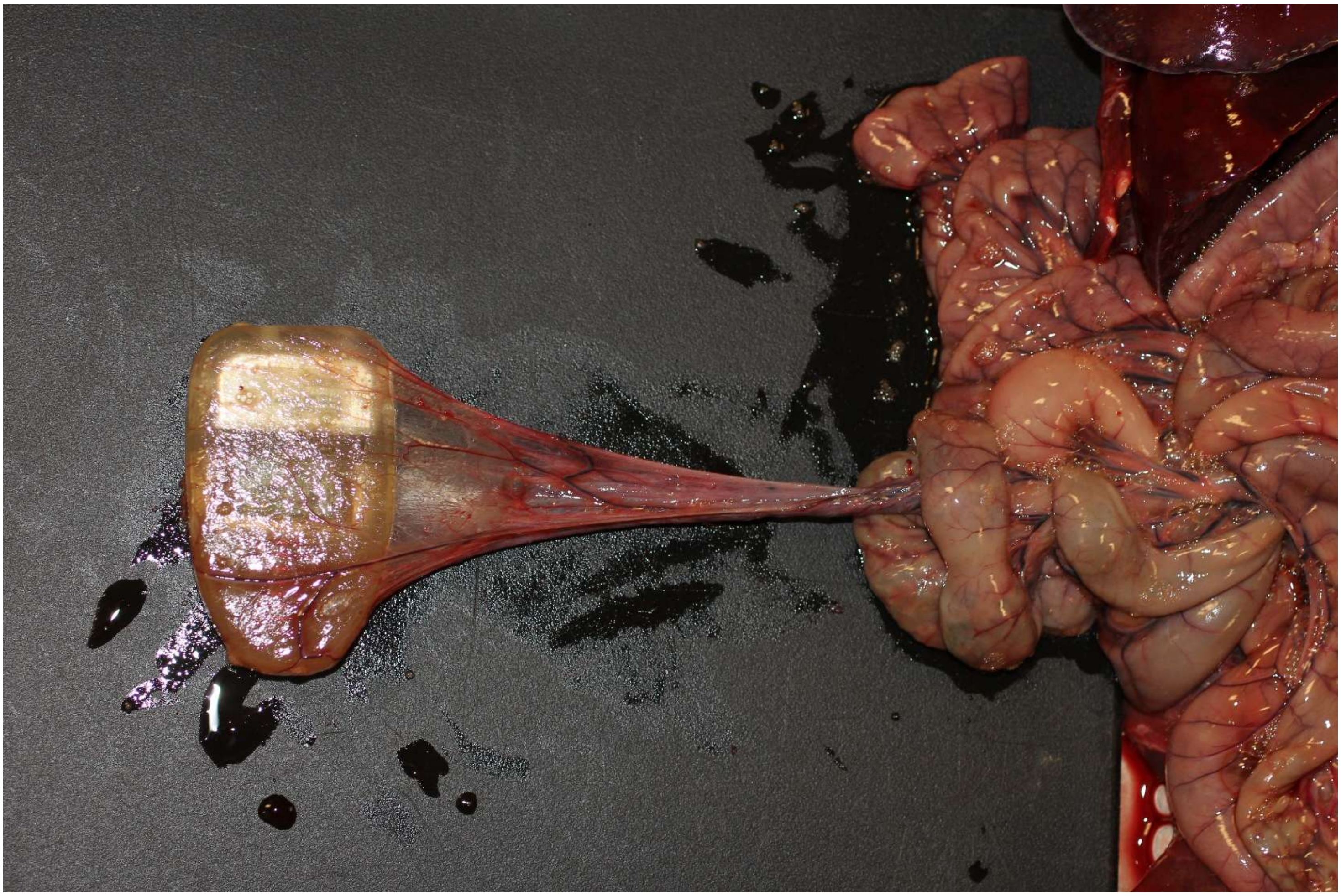
Closer view of the mass, which appears to be composed of degenerating omentum and adipose tissue (fat). The surrounding omental wall appears to be mildly “bunched”, & several small holes through the omental wall are apparent in the same area.



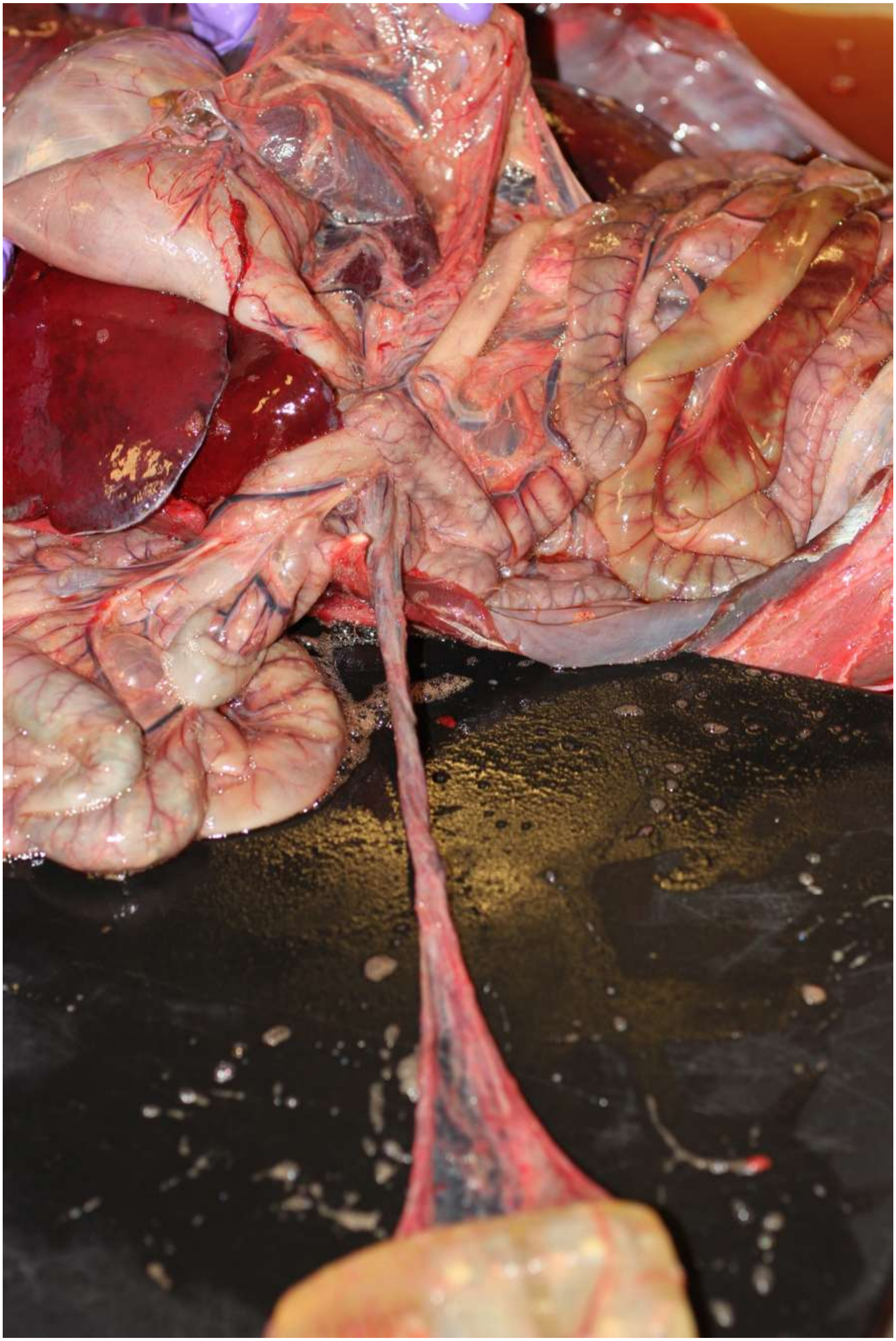
Closer view of the mass, which appears to be composed of degenerating omentum and adipose tissue (fat). The surrounding omental wall appears to be mildly "bunched", & several small holes through the omental wall are apparent in the same area.



The VHF transmitter was inside of the omental bursa at the outer edge of the omental sac, and was associated with mild twisting of the resulting omental stalk



The VHF was lightly adherent to the omental wall in the outer portion of the omental sac. VHF movement produced a long, mildly twisted omental stalk that was loosely wrapped around several loops of small intestine.



In this view most of the lightly entrapped intestinal loops have been unwrapped from the omental stalk. This image shows the mild twisting of the omental stalk, with the VHF within.

A small, discrete, non-communicating cystic structure was apparent on the outer wall of the esophagus. Pending histopathology this could be a congenital branchial cleft cyst (congenital gill remnant) which is interesting, but incidental.

Opened ovarian bursae, uterine horns and vaginal tract. Placental scars, & ovarian corpora albicantia & a possible follicle or early CL are apparent, identifying this as a stage 5 female (reproductive period spanning estrus through pre-implantation pregnancy).

Vargas, Darcy <darcy_vargas@fws.gov>

U.S Geological Survey PRT #672624

Joe Tomoleoni <jtomoleo@ucsc.edu> Mon, May 20, 2019 at 1:38 PM
To: "Barry, Anna" <anna_barry@fws.gov>
Cc: "Vargas, Darcy" <darcy_vargas@fws.gov>, Brian Hatfield <brian_hatfield@usgs.gov>, "Yee, Julie" <julie_yee@usgs.gov>

Hello Anna,

Thank you very much for the clarification. I believe my interpretation of columns (c) and (h) was exactly as you have described here, so the permit packet I submitted last Thursday should accurately reflect the correct information for question 21. If there is any confusion about our response, please let me know and we'll be happy to clarify. In the submitted application packet we requested 600 takes for sea otter captures (column c) and 1250 incidental harassment occurrences (column h) of non-target otters during the course of our capture activities. Both numbers are for the duration of the 5-year permit.

Thanks to both you and Darcy for your help with this. Please let us know if you have any questions.

Best,

Joe

Joe Tomoleoni
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BISON CONNECT

Vargas, Darcy <darcy_vargas@fws.gov>

U.S Geological Survey PRT #672624

Barry, Anna <anna_barry@fws.gov> Mon, May 20, 2019 at 12:07 PM
To: Joe Tomoleoni <jtomoleo@ucsc.edu>
Cc: "Vargas, Darcy" <darcy_vargas@fws.gov>

Good Morning Joe,

Thank you for providing the additional information, the deadline for providing the information is of course extended since you were waiting on our office to provide you clarification on the table found at question #21. The following I hope will provide this clarification.

The table is to help applicants itemize each of their "take" activities (ex. capturing, darting, aerial survey). Once you identify your "take" activities, you are to provide information on each of those "take" activities by addressing the headings in the table. So column (c) is listing your "take" activity(s) while column (h) is the number of animals incidentally harassed (not the targeted animals) while going after the targeted animal(s).

Let me know if we can assist further.

Sincerely,

Anna Barry
Supervisory Policy Specialist
USFWS/Division of Management Authority
Branch of Permits, MS: IA
5275 Leesburg Pike
Falls Church, VA 22041-3803
1-800-358-2104, ext. 1976 or 703-358-1976
Fax: 703-358-2281
E-mail: Anna_Barry@fws.gov

On Thu, May 16, 2019 at 7:40 PM Joe Tomoleoni <jtomoleo@ucsc.edu> wrote:

> Hello Darcy and Anna,
>
> Attached is a completed permit renewal application, revised as requested by Darcy in the email below. The only outstanding question we had that still remains unclear is the difference between Columns C & H in Table 2 (Question 21). Because today is the due date for the renewal application, I went ahead an interpreted this to the best of my ability. Column C represents the number of otters we are asking for permission to capture over the 5-yr duration of the permit (600 total captures), while Column H represents the total number of otters incidentally harassed during our

captures (1,250) for the entire 5-year duration of the permit. Please note that we provided a second table (Table 3) that further clarifies how many otters we plan to capture, instrument, and incidentally harass.

The cover letter describes how the application has been modified to address Darcy's questions, and also describes how we plan to modify our procedures as a result of the October 2018 research-related mortality.

Please let us know if you have any additional questions.

Thank you,

Joe
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jtomoleo@ucsc.edu

On Mon, Apr 1, 2019 at 9:27 AM Vargas, Darcy <darcy_vargas@fws.gov> wrote:

Dear Joe,

Ref: Application # 672624 to conduct research on Southern Sea otters.

I am reaching out in regards to your referenced application. Although, your application has already been reviewed by this office and has been sent off to internal reviewers within the U.S. Fish and Wildlife Service, your application was found to be too incomplete to forward to our external reviewers at this time. Please understand that we must have answers provided directly to the application questions. Many of the application questions referenced an enclosure package, which is okay. However, the enclosure then, often references other documents and/or question responses for answers to be inferred and/or researched. We do not have the means to do this and it is imperative that the application responses be clear and precise. Therefore, please review the following requests for additional information and clarity. Once this information is received, your application will be sent to our external reviewers. After at that time, we may have additional questions that need to be addressed before we publish this application request in the Federal Register.

1. Provide a numerical response to the application question on Part I, # 7.b (pg. 5).

2. Respond to application question on Part I, # 7.c. (pg. 5).

3. Respond to application question on Part I, # 8, and if applicable, # 8.h. and/or 8.i. (pgs. 5 & 6).

4. Please respond directly to application questions 20.a. of the application instead of referring to responses to other questions asked in the application.

5. Please respond directly to application questions 20.d. of the application. The current application response simply states "Question 10 has been completed."

6. Please respond directly to application questions 20.e. instead of referring to responses that could be found in *Lander et all* (2001). Each application question must have a direct response provided and the response should not reference information found in another location (a different application question, published paper, protocols, and/or enclosures).

7. Please respond directly to application questions 20.f.iii, 20.f.iv, 20.f.v, 20.f.vi. of the application. The responses to these questions simply states "Refer to Table 1, above."

8. Please respond directly to application questions 20.g.i, 20.g.ii, 20g.iii, 20.g.iv, 20.g.v. and 20.g.xiii. of the application. These questions were not responded to.

9. Please respond directly to application questions 20.hi. 20.h.ii, and 20.hiii. of the application. A general paragraph was provided, but none of these question were responded to directly.

10. In regards to question 20.i. of the application, please ensure to have provided all responses that you want reviewed directly in your response. It is noted that your response states to "see Table 1 for more information." However, we need clear and preci e re pon e and therefore, we will not infer your re pon e by reviewing the table

11. Your table provided in response to question 21 of the application is unclear. Why are the first 2 rows of the table left black for row c through i ? Plea e provide an updated table that i completed in entirety and that reflect your current and complete application requests.

12. Respond to question 22. of the application in entirety. The application response states "this has already been addre ed in Que tion 10, ection h " However, it i unclear a to what you are referring to by Section H of the application and regardless, each application question must be responded to directly.

13. Regarding female-pup calf pairs, your application clearly identifies that research is intended to be conducted on the pair Therefore, plea e clarify how impact would be minimized Pup weighing le than 11 pound won't be flipper tagged. Will anything else be done? The response to question 23 states that "very small pups are generally avoided when attempting to capture sea otters." Another application response states that pups 1-2 weeks of age won't be targeted, yet your application requests to work on all age classes. Those responses contradict each other. Therefore, plea e provide updated and con i tent application re pon e regarding re earch propo ed to be done on pups and female-calf pairs. Also, ensure to responds directly to application questions requesting information on what procedures are being requested for each activity via age class and what precautions would be taken.

14 Plea e re pond directly to que tion 25 of the application and e plain how the re earch will involve the lea e possible degree of pain without referencing other documents. The application response states "refer to methods in Question 10 and in this most recent section ,a as well as our IACUIC SOPs, and numerous published peer-review papers provided in this application."

15. Respond to question 29.a. through 29.j. of the application and provide the requested table, in table format.

16. Respond to application question 29.k.vi. of the application in entirely. The application response states "N/A." However, the application re pon e al o confirm that ample will be from wild animal Therefore, a re pon e to the question is required because intrusively collected samples are being proposed to be taken from wild sea otters. This question is applicable for our review purposes.

17 Re pond to application que tion 29 l in entirety The application re pon e tate "Refer to Table 1, and the additional information provided in (k), above."

18. Please clarify your responses to application questions 20 and 30. The following names were included in the application re pon e to name of per onnel who will conduct the ampling However, the e ame name were not included in your list of all personnel that will be involved in the project: Cara Field, Shawn Johnson, Clarie Simeone, Dave Casper, Marissa Yound, and Michelle, Staedler.

19 The cover letter enclo ed with the application package tate that the only amendment being reque ted i to add 3 personnel to the project. However, the application responses do not support that statement. Therefore, please provided a final confirmation of all personal whom are being requested to be included as co-investigators.

- Question 30 of the application requests to add Zachary Randell as a new co-investigator. However, he was included on USGS's previously issued permit.
- The following per onnel were not included a amendment to add a co inve tigator and were not included in the application response to question 30. However, these names were included in the list of personnel who will conduct the sampling (pg. 25 of the application enclosure). They were not previously included on USGS's permit. Therefore, they appear to be new amendment requests.

  --Shawn Johnson (DMV)
  Cara Field (DMV)
  --Claire Simeone (DMV)
  --Marissa Young
  --Michelle Staedler

20. CVs were provided for Zachary Randell, Tim Tinker, and Dave Casper. Thank you. However, you must also provide the CVs for every other PI and co-investigator (including samplers) being requested to be included in this renewal and amendment application. Also, please understand that we will not reference or look for CVs included as part of previou ly ubmitted application

21. Please provide your 2018 report.

In accordance with 50 CFR 13.ll(e), if the requested information is not received by this office by May 16, 2019 (45 calendar days of the date of this email), your application will be abandoned and administratively closed. Once a file is closed, you will need to submit a new application, and all required fees, for the Service to consider your proposed activity.

Respectfully,

Darcy Vargas
Biologist
US Fish and Wildlife Service
MS: IA
5275 Leesburg Pike
Falls Church, VA 22041-3803
www.fws.gov
www.cites.org

BISON CONNECT

Vargas, Darcy <darcy_vargas@fws.gov>

Research Application # 672624

Vargas, Darcy <darcy_vargas@fws.gov> Wed, May 29, 2019 at 8:33 AM
To: Joe Tomoleoni <jtomoleo@ucsc.edu>
Cc: Lilian Carswell <lilian_carswell@fws.gov>

Good morning Joe,

Ref: 672624

Thank you for providing your 2018 report and updated information/application.

Once we receive a copy of your 2016 & 2017 reports, we will forward your complete application (both original & updated application combined) to the Marine Mammal Commission for their comments and questions. Then, after our consultation with the Commission, we will likely reach out to you one additional time for final questions and/or clarifications. Also, please note that your updated May 16, 2019, application page one was not signed. However, for now, since we are anticipating going back to you one more time, it is fine.

I realize that for the past few years, this office was requiring entirely new applications to be submitted with each request for additional information. Please note, that in an effort to streamline our application processing and to lower the public burden time to complete applications, we are no longer requiring entirely new applications to be submitted, but instead, we typically only need responses to questions asked (to save you time in the future).

Kind Regards,

Darcy

--
Darcy Vargas
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www.cites.org

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Vargas, Darcy <darcy_vargas@fws.gov>

question regarding transfer of sea otter samples

Tomoleoni, Joseph <jtomoleoni@usgs.gov> Fri, Jun 21, 2019 at 2:42 PM
To: Darcy Vargas <darcy_vargas@fws.gov>

Hi Darcy,

We would like to send some samples (sea otter fat biopsies) to collaborators at Dalhousie Univeristy in Canada, for analysis on a joint project. These samples were taken under earlier versions of our permit (MA672624), when the permit holder was M. Tim Tinker. The permit was transferred to me in 2017, so I think I am now the responsible party.

Does our existing permit allow the transfer or these samples to our collaborators, or is there something further that needs to be done?

Thank you,

Joe
--
Joe Tomoleoni
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BISON CONNECT

Vargas, Darcy <darcy_vargas@fws.gov>

question regarding transfer of sea otter samples

Tomoleoni, Joseph <jtomoleoni@usgs.gov> Wed, Jun 26, 2019 at 6:56 PM
To: "Vargas, Darcy" <darcy_vargas@fws.gov>

Hi Darcy,

Thank you for the information. Could you please let me know what permit application/form number we would have to complete in order to export our samples to our collaborators in Canada?

Sorry for the delay on the signing of the permit application. I didn't realize that the actual application wasn't signed. I have reattached the entire application packet here, with my signature.

The copy of the permit that you are looking at (which was attached to your most recent email from earlier today) is an older version (version 16). Our most recent permit that we are renewing is attached here in 2 versions. The first was our initial permit issued #672624-18 for the period of 2013-2018. The second attachment is our most recent revision (#672624-20), listing myself and Brian Hatfield as the permit holders.

I will send the 2017 permit report in a separate email, due to attachment size restrictions. Please let me know if you have any questions about what is included here.

Thank you,

Joe
--
Joe Tomoleoni
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jtomoleoni@usgs.gov

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3 attachments

Combined_application_packet_2019May16.pdf
10560K

9-13-13 672624-18 USGS FNL PRT corrected.pdf
288K

18-03-16_672624_final.pdf
270K

May 13, 2019

Dear Darcy and Anna:

Enclosed you will find our revised application for the renewal and amendment of our current permit #MA672624-20, addressing all of your questions from our email correspondence on April 1, 2019. Note that in order to make sure we have clearly answered your questions from the April 1 correspondence, we have included a section that specifically lists your questions and our responses, in addition to addressing each question in the actual application packet. The revised Application for Renewal (Form 3-200-43) is included along with 45 additional pages to Form 3-200-43 starting with Section E.

Please note that we are requesting that our new permit essentially remain the same as our previous permit with a few exceptions. We are requesting to add 8 additional co-investigators, all of whom are exceedingly qualified and important to our work. Their qualifications and CV's are found within. Furthermore, in an attempt to alleviate any confusion, we have eliminated language referring to the "carry-over" of takes from our previous permit. Instead, we are simply stating the number of takes that we are requesting in our new permit. It should be noted that the new number requested happens to be very similar to the amount of unused takes from our prior permit.

We also want to specifically address the issue of the research-related mortality in the Fall of 2018. We discuss this issue in several difference sections of the permit, but we would like to summarize here. First, it is important to note that the animal in question died more than 2 years post-capture, so the complications were not acutely related to the capture or surgery. Necropsy determined that both surgically implanted instruments (TDR & VHF) were entrapped in the omentum and resulted in a fatal twisting. It is believed that the TDR popped out of the falciform ligament and became free-floating, which resulted in a cascade of events that caused both instruments to become entangled. If the TDR would have remained in place in the falciform ligament, there is a reasonably good chance that this otter would have survived without serious complications. Because of this finding, and the fact that there have been other issues with free-floating TDR entrapment in the omentum, we are currently seeking to refine our surgical procedure to make sure that the TDR remains in the falciform ligament and does not become free-floating. Dr. Mike Murray, our chief veterinarian from the Monterey Bay Aquarium, has proposed a novel approach that involves the use of an extracellular matrix (ECM) pouch (which is routinely used in human surgeries) to create a more robust pocket for the TDR. Extensive testing would need to be done on captive sea otters at the Monterey Bay Aquarium, so Dr. Murray and the Aquarium are currently working on an amendment request to pursue this technique under their permit.

Additionally, we are currently pursuing new tagging technologies (described in more detail in our application) that will hopefully allow us to start moving towards the use of more external tags. It has long been our goal to reduce the invasiveness of our tagging tech, and we are currently developing an electronic flipper tag that with have GPS capabilities to provide sea otter location data. This tag could also feature a pressure sensor which may allow it to fill the role of the TDR.

We recognize that both of the above solutions (surgical modification and new tag tech) require thorough testing and cannot be rushed. Therefore, we are proposing that effective immediately, we will suspend internal implants of all TDRs while we continue to work diligently on the above alternatives. This is not a decision that we have made lightly. TDRs have been tremendously valuable tools for sea otter research and nearly everything we know today about sea otter dive behavior (and much of what we know about reproductive energetics) comes from TDRs. However, we have always put the health and welfare of our sea otters above all else, and we believe that we are continuing to act in the best interest of the sea otters by suspending traditional TDR implants until a safer solution is developed. We are hopeful that we will be able to return to utilizing TDRs in the future in a manner that is safer for the otters. All language referring to the implant of TDR instruments has been removed from the permit application, but we are still requesting the ability to remove TDRs that were previously implanted under our earlier permits.

In additional to the main permit application, we've included a full copy of our current ACUC. Please note that the previous UCSC IACUC that we submitted with the original application in August is no longer valid, and our new USGS ACUC is now included in this revised packet. A three-page list of relevant publications that have stemmed from previous versions of our current FWS permit is also included for your reference.

Three separate research proposals for sea otter studies that are currently in progress under our existing permit have been enclosed in accordance with question 18 in the application.

If you have any questions or require any additional information, please do not hesitate to contact myself or Brian Hatfield, of the U. S. Geological Survey. Contact information is as follows:

Joe Tomoleoni: 831-254-9750, jtomoleoni@usgs.gov
Brian Hatfield: 805-305-2121, brian_hatfield@usgs.gov

Sincerely,

Joseph Tomoleoni
Enclosure

TO DO FOR USFWS PERMIT

1. Provide a numerical response to the application question on Part I, # 7.b (pg. 5).
Maximum expected number of animals harassed from #7a = 0.

2. Respond to application question on Part I, # 7.c. (pg. 5).
We do not expect any non-target marine mammals or ESA-listed species to be taken as a result of our activities, so the expected maximum number is 0.

3. Respond to application question on Part I, # 8, and if applicable, # 8.h. and/or 8.i. (pgs. 5 & 6). #8 is NO (N/A for the subsections)

4. Please respond directly to application questions 20.a. of the application instead of referring to responses to other questions asked in the application. DONE

5. Please respond directly to application questions 20.d. of the application. The current application response simply states "Question 10 has been completed." Per Darcy, the response “Question 10 has been completed” is appropriate here.

6. Please respond directly to application questions 20.e. instead of referring to responses that could be found in *Lander et all* (2001). Each application question must have a direct response provided and the response should not reference information found in another location (a different application question, published paper, protocols, and/or enclosures). DONE

7. Please respond directly to application questions 20.f.iii, 20.f.iv, 20.f.v, 20.f.vi. of the application. The responses to these questions simply states "Refer to Table 1, above." DONE

8. Please respond directly to application questions 20.g.i, 20.g.ii, 20g.iii, 20.g.iv, 20.g.v. and 20.g.xiii. of the application. These questions were not responded to. All responded to but there is no 20.g.xiii

9. Please respond directly to application questions 20.hi. 20.h.ii, and 20.hiii. of the application. A general paragraph was provided, but none of these question were responded to directly. DONE. All captive work is done in collaboration with the Monterey Bay Aqurium, under the existing MBA captive research permit, and thus, we don’t request any permission for captive work under our USGS permit.

10. In regards to question 20.i. of the application, please ensure to have provided all responses that you want reviewed directly in your response. It is noted that your response states to "see Table 1 for more information." However, we need clear and precise responses and therefore, we will not infer your response by reviewing the table. DONE

11. Your table provided in response to question 21 of the application is unclear. Why are the first 2 rows of the tables left black for rows c. through i.? Please provide an updated table that is completed in entirety and that reflects your current and complete application requests. This table has been adjusted for clarity. In order to simplify, we removed all references to the number of remaining takes on our current permit, and are simply stating how many takes we are requesting for this renewal. There was still some confusion on the difference between Column C and H. We interpreted those two columns as follows: Column C represents the number of otters we are asking for permission to capture over the 5-yr duration of the permit (600 total captures), while Column H represents the total number of otters incidentally harassed during our captures (1,250) for the entire 5-year duration of the permit. Please note that we provided a second table (Table 3) that further clarifies how many otters we plan to capture, instrument, and incidentally harass.

12. Respond to question 22. of the application in entirety. The application response states "this has already been addressed in Question 10, section h." However, it is unclear as to what you are referring to by Section H of the application and regardless, each application question must be responded to directly. DONE

13. Regarding female-pup calf pairs, your application clearly identifies that research is intended to be conducted on the pairs. Therefore, please clarify how impacts would be minimized. Pups weighing less than 11 pounds won't be flipper tagged. Will anything else be done? The response to question 23 states that "very small pups are generally avoided when attempting to capture sea otters."   Another application response states that pups 1-2 weeks of age won't be targeted, yet your application requests to work on all age classes. Those responses contradict each other. Therefore, please provide updated and consistent application responses regarding research proposed to be done on pups and female-calf pairs. Also, ensure to responds directly to application questions requesting information on what procedures are being requested for each activity via age class and what precautions would be taken. DONE and clarified.

14. Please respond directly to question 25 of the application and explain how the research will involve the lease possible degree of pain without referencing other documents. The application response states "refer to methods in Question 10 and in this most recent section ,a as well as our IACUIC SOPs, and numerous published peer-review papers provided in this application." DONE. Outside references removed, details expanded upon.

15. Respond to question 29.a. through 29.j. of the application and provide the requested table, in table format. New table created to answer these questions.

16. Respond to application question 29.k.vi. of the application in entirely. The application response states "N/A."   However, the application response also confirms that samples will be from wild animals. Therefore, a response to the question

is required because intrusively collected samples are being proposed to be taken from wild sea otters. This question is applicable for our review purposes. DONE

17. Respond to application question 29.l. in entirety. The application response states "Refer to Table 1, and the additional information provided in (k), above." DONE

18. Please clarify your responses to application questions 20 and 30. The following names were included in the application response to names of personnel who will conduct the sampling. However, these same names were not included in your list of all personnel that will be involved in the project: Cara Field, Shawn Johnson, Clarie Simeone, Dave Casper, Marissa Yound, and Michelle, Staedler. Michelle was on previous permits so is not new. We have listed 8 people that we are requested to be added to the permit. CVs for all personnel (new and exsiting) are attached in this packet

19. The cover letter enclosed with the application package states that the only amendment being requested is to add 3 personnel to the project. However, the application responses do not support that statement. Therefore, please provided a final confirmation of all personal whom are being requested to be included as co-investigators.

- Question 30 of the application requests to add Zachary Randell as a new co-investigator. However, he was included on USGS's previously issued permit.
- The following personnel were not included as amendments to add as co-investigators and were not included in the application response to question 30. However, these names were included in the list of personnel who will conduct the sampling (pg. 25 of the application enclosure). They were not previously included on USGS's permit. Therefore, they appear to be new amendment requests.

--Shawn Johnson (DMV)
--Cara Field (DMV)
--Claire Simeone (DMV)
--Marissa Young
--Michelle Staedler

Michelle Staedler has been on all previous versions of this permit and is not new. We are requesting that Shawn Johnson, Cara Field, Claire Simeone, Marissa Young, Julie Yee, Nicole Thometz, Dave Casper, and Tim Tinker be added to the permit.

20. CVs were provided for Zachary Randell, Tim Tinker, and Dave Casper. Thank you. However, you must also provide the CVs for every other PI and co-investigator (including samplers) being requested to be included in this renewal and amendment application. Also, please understand that we will not reference or look for CVs included as part of previously submitted applications.
All CVs for all personnel are included in the packet.

21. Please provide your 2018 report.
Included in the packet.

Department of Interior
U.S. Fish and Wildlife Service

Federal Fish and Wildlife Permit Application Form

U.S. Fish and Wildlife Service
Division of Management Authority
Branch of Permits, MS: IA
5275 Leesburg Pike
Falls Church, VA 22041-3803
1-800-358-2104 or 703-358-2104

Type of Ac ivity

Take/Import/Export of Marine Mammals for Public Display, Scientific Research, Enhancement, or Rescue/Rehabilitation/Release Activities or Renewal/Amendment of Existing Permit (*MMPA and/or ESA*)

Complete Sections A or B, and C, D, and E of this application. U.S. address may be required in Section C, see instructions for details.
You may find instructions on how to make your application complete and help avoid unnecessary delays at the following link:

Section A: Complete if applying as an individual

1.a. Last Name	1.b. First Name	1 c. Middle Name/Initial	1.d. Suffix
Tomoleoni	Joseph	A	

2. Date of Birth (mm/dd/yyyy)	3. Telephone Number	3.a. Alternate Telephone Number	4. E-mail address
[redacted]	831-254-9750		jtomoleoni@usgs.gov

Section B: Complete if applying on behalf of a business, corporation, public agency, Tribe, or institution

1.a. Name of business, agency, Tribe, or institution	1 b. Doing business as (DBA)
2. Tax identification no.	3. Description of business, agency, Tribe, or institution

4.a. Principal officer Last name	4.b. Principal officer First Name	4.c. Principal officer Middle name/initial	4.d. Suffix

5. Principal officer title	6. Primary contact name

7.a. Business telephone number	7.b. Alternate telephone number	7.c. Business fax number	7.d. Business e-mail address

Section C: All applicants complete address information

1.a. Physical address (Street address; Apartment #, Suite #, or Room #; no P.O. Boxes)				
2885 Mission Street				
1.b. City	**1.c. State**	**1 d. Zip code/Postal code**	**1 e. County/Province**	**1.f. Country**
Santa Cruz	CA	95060	Santa Cruz	USA
2.a. Mailing address (include if different than physical address; include name of contact person if applicable)				
2.b. City	**2.c. State**	**2 d. Zip code/Postal code**	**2 e. County/Province**	**2.f.Country**

Section D: All applicants MUST complete

1. Attach the **non-refundable application processing fee,** in he form of a check or money order, payable to the U.S. FISH AND WILDLIFE SERVICE **in the amount identified on page 3**. Federal, Tribal, State, and local government agencies, and those ac ing on behalf of such agencies, are exempt from the processing fee – *attach documentation of fee exempt status as outlined in instructions.* [50 CFR 13.11(d)].
2. Certification: I hereby certify that I have read and am familiar with the regulations contained in ***Title 50 Part 13 of the Code of Federal Regulations*** and he other ***applicable parts in subchapter B of Chapter I of Title 50***, and I certify that the information submitted in this application for a permit is complete and accurate to the best of my knowledge and belief. I understand that any false statement herein may subject me to the criminal penalties of 18 U.S.C. 1001.

Signature of applicant/Principal Officer for permit (No photocopied or stamped signatures)   Date of signature (mm/dd/yyyy)

Please continue to next page

E. Take/Import/Export of Marine Mammals for Public Display, Scientific Research, Enhancement, or Rescue/Rehabilitation/Release Activities or Renewal/Amendment of an Existing Permit (Species listed in the MMPA and/or species listed in both the MMPA and ESA)

Allow at least 90 days for the application to be processed. Applications for marine mammal permits must be published in the Federal Register for a 30-day public comment period.

Use this application for the take[1], import, export, or re-export of marine mammal species (or their parts) under the jurisdiction of the U.S. Fish & Wildlife Service (sea otters, marine otter, polar bears, walrus, manatees, and dugongs; see the marine mammal policy fact sheet) for purposes of public display of live animals, scientific research, or enhancement under the U.S. Marine Mammal Protection Act (MMPA) and/or U.S. Endangered Species Act (ESA). This application may also be used to apply for a letter of authorization (LOA) under MMPA Sections 109(h)/112(c) and/or an ESA permit for enhancement of propagation or survival of the species, which would provide authorization to work as a "cooperator" for the purpose(s) of **rescue, rehabilitation, and/or release of stranded marine mammals.** Finally, this application may be used for the **renewal and/or amendment** of an existing permit for these activities.

Note: Renewal and amendment requests require responses to all questions pertaining to your requested activity.

This form should NOT be used:

- For activities involving marine mammals under jurisdiction of the National Marine Fisheries Service (NMFS) (i.e., whales, dolphins, porpoises, seals, and sea lions), please contact NMFS.
- For activities involving photography in the wild for educational or commercial purposes, use Form 3-200-86.
- For transport/transfer of live captive-held animals within the United States, use Form 3-200-87.
- For transfer within the United States of dead marine mammal specimens for the purpose of public display or scientific research, use Form 3-200-87.

If you already have MMPA/ESA authorization and need a CITES permit:

- For CITES export/re-export of captive-held **LIVE** animals, use Form 3-200-53.
- For, export, or re-export of parts or biological samples, use Form 3-200-29; for import of parts of Appendix-I animals, use Form 3-200-37; and for introduction from the sea, use Form 3-200-31.
- Provide a copy of your FWS or NOAA Fisheries permit or authorization with your CITES permit application.

All international shipment(s) must be through a designated port. A list of designated ports (where an inspector is posted) is available from the list of designated ports. If you wish to use a port not listed, please contact the Office of Law Enforcement for a Designated Port Exemption Permit (form 3-200-2).

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[1] The term, "take," as defined by the MMPA means to harass, hunt, capture, or kill, or attempt to harass, hunt, capture, or kill any marine mammal. As defined by the ESA, "take" means to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct.

PERMIT TYPES AND PROCESSING FEES

Please review the complete application carefully before beginning. Provide complete answers to all the questions in the sections relevant to the activity for which you are requesting authorization. If a question is not applicable, answer with "N/A." You will need to use additional sheets of paper. On all attachments or separate sheets you submit, indicate the application question number you are addressing. If you are applying for multiple species and/or activities, be sure to indicate which species/activity(ies) you are addressing in each response.

Electronic submission of inventories, photographs, and receipts: Some applications contain extensive inventories and/or a large number of photographs or receipts. You may provide electronic versions of the documents. Such a submission will assist in the processing of your application since it may reduce data entry by the U.S. Fish and Wildlife Service. If you wish to provide information electronically, once you have received an application number via the e-mailed acknowledgement letter, e-mail your information to Permits@fws.gov. Be sure to include the application number provided in the acknowledgement e-mail that will be sent to you when we receive your application.

☐ **I will be submitting documents electronically.**

PURPOSE for which you are applying (check below):

☐ PUBLIC DISPLAY of live animals (Processing Fee = $**300**): **Complete All of Part I and Part II**.

NOTE: A public display permit is not available for marine mammal species listed as depleted under the MMPA or listed under the ESA; a public display permit may be valid for the life of an animal and is not renewable; a public display permit may be available for a facility that would hold multiple animals of a particular species and would be renewable every 5 years.

☑ SCIENTIFIC RESEARCH (Processing Fee = $**150**): **Complete All of Part I and Part III**.

☐ RESCUE, REHABILITATION, and/or RELEASE of stranded marine mammals (Processing Fee = $**150**): **Complete questions 1-7 of Part I and Part IV**.

☐ MMPA ENHANCEMENT of survival or recovery of the species or stock (Processing Fee = $**150**): **Complete Part I and Part V**.

Request is for (check below):

☐ NEW PERMIT (See processing fee above).

☑ RENEWAL of Permit # MA672624-2 (See processing fee above; Complete all questions for your requested activity, as described above).

☐ AMENDMENT of Permit # ____________ (For Scientific Research, Rescue/Rehabilitation/Release, or MMPA enhancement, amendment fee = $75, and for Public Display = $150).

If requesting renewal or amendment of your current permit, provide an update of any activity that has occurred under the permit since your last report.

PART I.

1. Name and address where you wish the permit to be mailed, **if different from page 1**. If you would like expedited shipping, please enclose a self-addressed, pre-paid, computer-generated, courier service airway bill. If unspecified, all documents will be mailed via the U.S. Postal Service.

   same address as Page 1

2. Who should we contact if we have questions about the application (name, phone number, and e-mail)?

   First contact: Joseph Tomoleoni, 831-254-9750, jtomoleoni@usgs.gov
   Secondary contact: Brian Hatfield, 805-305-212, bhatfield@usgs.gov

3. Disqualification factor. A conviction, or entry of a plea of guilty or nolo contendere, for a felony violation of the Lacey Act, the Migratory Bird Treaty Act, or the Bald and Golden Eagle Protection Act disqualifies any such person from receiving or exercising the privileges of a permit, unless such disqualification has been expressly waived by the Service Director in response to a written petition. (50 CFR 13.21(c)) Have you or any of the owners of the business, if applying as a business, been convicted, or entered a plea of guilty or nolo contendere, forfeited collateral, or are currently under charges for any violations of the laws mentioned above?

   ☐ No ☐ Yes

   If you answered “Yes” to Question 3, provide: a) the individual’s name; b) date of charge; c) charge(s); d) location of incident; e) court; and f) action taken for each violation. Please be aware that a “Yes” response does not automatically disqualify you from getting a permit.

4. List the scientific name (genus, species, and, if applicable, subspecies), and common name of each species for which you are applying.

   Enhydra lutris nereis, Southern sea otter

5. Provide a copy of any other applicable Federal, local, or state permissions (e.g., National Wildlife Refuge Special Use Permit, NOAA National Marine Sanctuary permit, etc.) required to conduct your proposed work, OR indicate whether you have applied for, secured, or will apply for such permissions (please provide contact information).

6. Is/are the species or population stock(s) for which you applying listed under the U.S. Endangered Species Act (ESA), a species proposed for listing, or a candidate species?

   ☐ **NO** ☐ **YES;** complete a-d, below.

   a. Attach a justification for taking an ESA-listed species, and explain why your proposed activities are not appropriate for a similar non-ESA-listed species;

   b. Describe both the short- and long-term anticipated effects of each of your activities alone or cumulatively on the behavior and physiology of the target animals and critical habitat or proposed critical habitat for the species.

c. Describe how the animals will react to your actions and the consequences of those reactions.

see attached pages

d. Identify how you would mitigate any potential negative effects.

see attached pages

7. Do you plan to conduct activities with **MARINE MAMMALS IN THEIR NATURAL ENVIRONMENT (**i.e., in the wild) where "non-target" marine mammal and ESA-listed species occur in the United States? ("Non-target" species are species that are not the subject of your activities.)

☐ **NO** ☐ **YES**; We will need to assess impacts to marine mammal and ESA-listed species that are not the subject of your activities; therefore, provide responses to a-c, below:

a. A list of all non-target marine mammals and ESA-listed species that might occur in your project area or might be affected by your activities;

see attached

b. The maximum number of animals of each non-target marine mammal and ESA-listed species (# per species) that might be harassed by your activities, the precautions that you will take to minimize the likelihood that harassment will occur, and the actions that you will take should harassment occur; and

see attached

c. The maximum number of animals of each non-target marine mammal and ESA-listed species (# per species) that might be taken (e.g., killed, injured, feeding activities disrupted, etc.) by your activities, your precautions to minimize the likelihood that take will occur, and your actions should take occur.

We do not expect any non-target marine mammals or ESA-listed species to be taken as a result of our activities, so the expected maximum number is 0.

(Note: The following link provides access to resources that might be useful to you in gathering the required information to answer this question, including links to FWS and NMFS offices responsible for managing marine mammals stocks, and Stock Assessment Reports, which provide population status information on marine mammal stocks.

8. Do you plan to conduct your public display, research, or MMPA enhancement activities with **MARINE MAMMALS that are CURRENTLY HELD IN A CAPTIVE ENVIRONMENT (including, but not limited to import into the U.S. of captive-held live animals/specimens)**

☐ NO ☐ YES; specify the number of captive individuals for each species of interest: _____and for each individual animal of each species of interest, respond to a-g, h and i below.

Note: You may provide the information in tabular form, as in the example below:

a. Species	**b.** Sex	**c.** Birth date	**d.** Description (e.g., ID #, ISIS #, transponder #, tattoo #)	**e.** Country of origin	**f.** Source (i.e., wild, captive-born, or captive-bred)	**g.** Current location of animal
Example: *Enhydra lutris kenyoni*	Female	Approx. 04/09/2010	House # XXX123 Transponder # 45678	USA	wild	ABC Aquarium, Anchorage Alaska

h. For **captive-born or captive-bred animal(s)**, provide a breeder's statement, ARKS/ZIMS specimen report, or other information that documents the animal was born in captivity, location of birth, and information on the source of the parental stock (e.g., captive-born, wild).

i. For **captive-held animal(s) already taken from the wild**, provide:

i. Information (e.g., ARKS/ZIMS specimen report(s)) on the source of the animal, including when the animal was removed from the wild, by whom, and the location.

ii. A copy of the MMPA permit or LOA under which the animal is currently being held in captivity or a copy of the MMPA permit or authorization authorizing removal of the animal from the wild.

iii. Has the U.S Fish and Wildlife Service deemed the animal(s) non-releasable to the wild?

☐ **YES**; provide a copy of the official letter confirming the animal's non-releasable status.

☐ **NO**; if you are requesting to have the animal(s) deemed non-releasable at this time, provide an explanation of the following: a) why release of the animal to the wild will not likely be successful given its physical condition; b) why release of the animal to the wild will not likely be successful given its behavior including adverse interactions with humans or marine mammals; **or** c) why release of the animal to the wild may jeopardize the wild population of the species.

9. For animal(s) to be taken from the wild and brought into a captive environment for public display, research, or MMPA enhancement activities, provide for each species:

a. Information on the actual or proposed date(s) and location(s) of collection;

b. The numbers of animals of each age class and sex to be taken from the wild (include a definition of each of these age classes by range of # months and/or years).

c. An estimate of the species' population stock in the wild; Note: stock assessment reports might assist you with this information and are available at the following FWS field offices, depending on the species involved:

Southern sea otter: Ventura Fish and Wildlife Office

Northern sea otter: Washington Fish and Wildlife Office

Northern sea otter, walrus, polar bear: Marine Mammals Management, AK

Manatee: North Florida Ecological Service Office

d. A description of the efforts made to acquire captive-held animals, in lieu of taking animals from the wild.

(Note: for holding and maintaining animals you must also provide the information requested in question 14.)

10. Are you requesting to **CAPTURE LIVE** marine mammals in the wild? (i.e., for research, public display, or MMPA enhancement)

☐ NO ☐ **YES**; specify the number of individuals to be captured for each species of interest: up to 600 and provide a – i, below:

a. A description of the manner in which the animal will be captured, type of gear used, and deployment method (e.g., from shore or boat approach and net deployment).
b. Methods of restraint and holding, including dimensions/type of holding container, if used;
c. The holding time required prior to transport or release of the animal;
d. Number and roles of personnel participating in the captures;
e. Duration of restraint/holding from capture to release; and
f. The number of non-target individual animals of the target species that will be incidentally harassed during capture activities, and precautions you will take to minimize incidental harassment of non-target animals;
g. If capturing females with calves/pups/cubs, describe:
   i. How calves/pup/cubs will be held;
   ii. Which procedures will be conducted on them;
   iii. The duration of time the pair will be separated; and
   iv. Procedures used to reunite the pair, and if they do not reunite, explain the disposition of the calf/pup/cub.
h. A description of the use of drugs during capture, including:
   i. Name of each drug/chemical used, its dosage rate (ml/kg), method of administration (IV, IM, SQ, topical and whether remotely-deployed IM), and purpose of the drug;
   ii. Duration of drug and required holding time;
   iii. The names of the personnel who would administer the drugs;
   iv. Provisions to minimize adverse reaction(s), including the use of appropriate drug reversals;
   v. Procedures to be used to minimize the chance that drugged animals will escape or enter the water prior to complete immobilization; and
   vi. Measures to be taken to ensure that the animal is fully recovered prior to release.
i. What emergency procedures would be employed (e.g., drugs, bagging, CPR, etc.) in the event that an animal's condition starts deteriorating during capture activities?

11. Are you requesting to **IMPORT LIVE** marine mammals?

☐ NO ☐ **YES**; specify the number of individuals to be imported for each species of interest: ____________ and provide a – m, below:

a. The proposed date of import;
b. The name and address of the foreign exporter, including the country of export;
c. For wild-sourced animal(s), a description of the manner in which it was taken from the wild and a copy of the foreign collecting/capture authorization(s);
d. The age (approximate or known) of the animal at the time of removal from wild or from its mother;
e. The age (approximate or known) of the animal at time of weaning; and
f. For females, respond to i & ii, below:
   i. At the time of removal from the wild, was the female pregnant? ☐ NO ☐ YES
   ii. At the time of the proposed import, will the female be pregnant? ☐ NO ☐ YES
g. A description of the means and duration of the transportation used to move and import the animals;
h. A description of the type, size, and construction of all shipping containers used to transport the animals;
i. A description of the arrangements for watering or otherwise caring for the animals during transport;
j. A description of the qualifications of each person accompanying the animal that demonstrates their ability to address the animal's needs during transport;
k. A copy of the transport plan;

l. Quarantine plans, including location and time-frame; and
m. Any additional documentation showing compliance with U.S. Department of Agriculture (USDA) regulations for transport and care of live marine mammals (7 U.S.C. 2131-2159; 9 CFR 3, Part E).

NOTE: A separate CITES permit will be required from our office prior to the import of live CITES Appendix I species.

12. Are you requesting to **IMPORT PARTS/SPECIMENS** of/from marine mammals?

☐ **NO** ☐ **YES**; provide a – m, below:

a. The proposed date of import;
b. The name and address of the foreign exporter, including the country of export;
c. The current location of the specimens;
d. The country of origin of the animals from which the specimens were/will be collected;
e. List the number of animals by species, age class/life stage, and sex from which parts/samples are sought. If you are requesting opportunistic sample import, you may request an unlimited number of samples from a specified number of animals, by taxa (e.g., unlimited samples from up to 100 polar bears annually).
f. The types of specimens to be imported (e.g., blood, skin biopsy, carcasses, etc.) and number of each type from each animal;
g. The source of the specimens to be imported (wild, captive-bred, or captive born);
h. Were the animals/will the animals be alive or dead at the time of sample collection?

   ☐ DEAD ☐ LIVE

i. Provide a detailed description of the source of the specimens to be imported and the manner in which the sample was/will be taken or collected. For example, this might include the following sources:
   i. Animals in captivity (samples taken during routine husbandry procedures or under separate authorization; distinguish between permanently captive in public display or research facility or temporarily captive in rehabilitation facility);
   ii. Animals in foreign countries stranded alive or dead or that died during rehabilitation;
   iii. Animals killed during legal subsistence harvests;
   iv. Animals killed incidental to legal commercial fishing operations;
   v. Samples from other authorized researchers or collections;
   vi. Soft or hard parts that are sloughed, excreted, or discharged naturally.
j. Provide a copy of the foreign collecting/capture authorization(s) (if not required, indicate “not required”);
k. If importing samples from subsistence-hunted marine mammals in foreign countries, describe the subsistence method. Include documentation, if available, that verifies that the taking was/will be conducted in a humane manner (i.e., using the method that involves the least possible degree of pain and suffering);
l. If importing samples from live animals, describe how the samples were/will be collected, including animal handling and sample collection protocols. This should include a description of how the take was humane; and
m. Describe how the specimens will be preserved, shipped, and stored/curated.

NOTE: A separate CITES permit will be required from our office prior to the import of specimens of CITES Appendix I species.

13. Are you requesting to **EXPORT or RE-EXPORT PARTS/SPECIMENS** of/from marine mammals?

☐ **NO** ☐ **YES**; provide a – e, below:

a. The types of specimens and quantity of each to be exported/re-exported;
b. The complete name and address of person/facility receiving the specimen(s);
c. A description of the origin of the specimens to be exported/re-exported;
d. The name(s) of the facility/institution that currently holds the specimens; and
e. Whether a portion of the specimen will need to be re-imported following export/re-export.

NOTE: A separate CITES permit will be required from our office prior to the export/re-export)

14. Are you a facility requesting **MAINTENANCE of LIVE ANIMALS (**i.e., holding and caring for animals) for public display, research or MMPA enhancement activities?

☐ **NO** ☐ **YES**; specify the number of individuals to be held for each species of interest: ________________;

and provide a – h, below:

a. A complete description, including photographs and/or diagrams (no blueprints), of the area and facilities where the animals will be held (including the dimensions of pools and haul-out areas);
b. The number of animals of the same species (include age and sex) presently maintained at the facilities and information indicating whether there is space for additional animals without exceeding USDA/Animal and Plant Health Inspection Service (APHIS) limits (i.e., provide the maximum # of animals of each species that could be held).
c. A list of all animal caretakers and a description of their specific duties/responsibilities;
d. A description of the animal caretakers' experience in the care, handling, and maintenance of the marine mammal species that is/are the subject of this application and copies of curriculum vitae (CVs) that demonstrate such experience for each caretaker;
e. A description of specific State requirements regarding who (e.g., attending veterinarians, vet technicians, researchers) may handle and administer certain drugs;
f. A list of all marine mammals under the jurisdiction of FWS maintained at the facility (specify whether they are held in the same exhibit/holding area as the target animals will be held and maintained);
g. A description of all deaths of FWS-jurisdiction marine mammal species at the facility within the past five years and the steps taken to prevent or decrease similar mortalities;
h. A copy of the facility's USDA/APHIS, Animal Welfare Act (AWA) license and the most recent APHIS inspection report.

15. If you are a facility requesting maintenance of live animals for which the primary purpose is scientific research, or enhancement of survival or recovery of the species, are you seeking approval to publicly display the subject animals?

☐ **NO** ☐ **YES**; in a-c, below, provide information to show that:

a. The facility is open to the general public without limitations or restrictions (other than by the charging of an admission fee);
b. The facility offers a program for education or conservation purposes that is based on professionally recognized standards of the public display community; and
c. Such display will not interfere with attainment of the objectives of the permitted/authorized activity.

PART II.

FOR PUBLIC DISPLAY

16. For U.S. facilities, provide information to show that the facility:
    a. Is open to the general public without limitations or restrictions (other than by the charging of an admission fee);
    b. Offers a program for education or conservation purposes that is based on professionally recognized standards of the public display community (include copies of outreach/educational materials and photos of signage); and
    c. Is registered or holds a license issued by the USDA Animal and Plant Health Inspection Service (APHIS) under the Animal Welfare Act (AWA).

PART III.

FOR SCIENTIFIC RESEARCH

17. Explain how the proposed research meets the MMPA definition of "bona fide research," i.e., scientific research on marine mammals, the results of which: (A) are likely to be accepted for publication in a referenced scientific journal; (B) are likely to contribute to the basic knowledge of marine mammal biology or ecology; or (C) are likely to identify, evaluate, or resolve conservation problems.

    see attached.

18. Provide a detailed description of the proposed project. You may attach a formal research proposal, provided it includes all the requested information, including:

    a. Objectives and hypotheses and associated methodology;

    b. Background information discussing relevant published literature on the subject of your proposal, with citations;

    c. An explanation of how this study is different from, builds upon, or duplicates past research;

    d. An explanation of how you determined your sample size/take numbers (e.g., based on previous encounter rates or abundance estimates for the study area). If appropriate for your study, include a power analysis or other sample size estimation to show whether the sample size is sufficient to provide statistically significant or otherwise robust results appropriate for your study;

    e. If proposing novel procedures, include a discussion on results from pilot studies or studies on other species, if available; and

    f. Disposition of animals or remaining specimen material once your project is complete.

19. Provide the expected research schedule (clearly specify the proposed start date and end date of your research or field season(s) and overall duration of the project). Include the months of the year and frequency of fieldwork/sampling (e.g., number of times per year). If your research extends beyond five years, or is a continuation of previously authorized research, give information about when the research began and when you expect it to end.

Level A harassment means any act of pursuit, torment, or annoyance, which has the potential to injure a marine mammal or marine mammal stock in the wild.

Level B harassment means any act of pursuit, torment, or annoyance, which has the potential to disturb a marine mammal or marine mammal stock in the wild by causing disruption of behavioral patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering.

Take, as defined by the MMPA means to harass, hunt, capture, or kill, or attempt to harass, hunt, capture, or kill any marine mammal.

20. Indicate which research procedures/activities you will be conducting that will or might result in **TAKE or HARASSMENT of TARGET species**, and describe each activity in detail, including the information indicated in a-i, below.
   a. Administration of drugs (including emergency drugs and prophylactic antibiotic use) or other substances (e.g., stable isotopes); include i-vii, below, in your activity description:
      i. Name of each drug/chemical used, its dosage rate (ml/kg), method of administration (IV, IM, SQ, topical and whether remotely-deployed IM), and purpose of the drug;
      ii. Duration of drug and required holding time;
      iii. The names of the personnel who would administer the drugs;
      iv. A description of specific State requirements regarding who (e.g., attending veterinarians, vet technicians, researchers) may handle and administer certain drugs;
      v. Provisions to minimize adverse reaction(s), including the use of appropriate drug reversals;
      vi. Procedures to be used to minimize the chance that drugged animals will escape prior to complete immobilization; and
      vii. Measures to be taken to ensure that the animal is fully recovered prior to release.

   b. Aerial and vessel surveys (manned); include i-v, below, in your activity description:
      i. Type of survey craft and vessel;
      ii. Type of survey (e.g., line transect, photogrammetry);
      iii. Number of surveys per year;
      iv. Minimum and maximum altitude/approach distance; and
      v. Duration spent with group or individual per day.

   c. Aerial surveys using unmanned aircraft systems (UAS); include i-xii, below, in your activity description:
      i. Dimensions, mass, and battery life of UAS;
      ii. Will the UAS ever be beyond the line of sight?
      iii. Does the device have an auto-return feature should the device fail?
      iv. Ground control station description (what it is, where it will be located, e.g., on shore or on vessel, number of stations, and how close the station will be to animals);
      v. Spotter roles (e.g., one spotter monitoring the UAS, another for monitoring the ground control station);
      vi. Do you have the appropriate FAA permits/authorizations (including pilot licenses)?
      vii. Type of survey (e.g., line transect, photogrammetry);
      viii. Number of surveys per year;
      ix. Minimum and maximum altitude/approach distance;
      x. Duration spent with group or individual per day;
      xi. The names of the personnel who will pilot the aircraft, and
      xii. Mitigation measures you will use to minimize disturbance including specific measures you will use to avoid separating female-calf/pup/cub pairs, and measures to ensure the UAS will not collide or crash into any of the animals.

   d. Capture and restraint; if you will be capturing animals, ensure that you have completed question 10, above.
   e. Instrumentation, Marking, and Tagging (MTI); include i-x, below, in your activity description:
      i. The type of MTI (including dimensions and mass);
      ii. The maximum number and total mass of MTIs to be attached to/implanted in an animal at a given time;
      iii. The maximum dart penetration depth if MTI is attached via darts;
      iv. Methods and location of attachment, including minimum approach distance for remote MTI attachment;
      v. If surgeries for implantable tags are being conducted, specify who will be conducting them, where (in the field or in a facility), and if antibiotic prophylactics will be administered;
      vi. The maximum number of times an animal would be fitted with MTIs in a given year;
      vii. Will recapture be necessary (if so, how many times will animals be captured annually), would the instrument/tag have a release mechanism, or would the instrument/tag fall off?

viii. Have the proposed MTIs been used previously on this species?
ix. What are the potential adverse effects and the means of monitoring new MTIs for adverse effects?
x. What actions will be taken in the event that the MTI has a significant adverse impact on the animal(s), and what is the method of animal release from the MTI?

f. Intrusive sampling (e.g., blood, blubber, muscle, skin); include i-xiii below, in your activity description:
i. Will sampling be remote or under restraint?
ii. Will local anesthetics be administered?
iii. Type of tissues sampled;
iv. Size or volume of sample (diameter and depth or total volume);
v. Target sampling location on body;
vi. Maximum number of samples per animal per day and per year;
vii. Sampling intervals (e.g., for serial blood or biopsy samples);
viii. Collection method and equipment/materials used (e.g., dart fired from rifle, dart depth, sterilization/disinfection);
ix. If remote, what is the minimum approach distance?
x. If restrained, describe treatment of site of sample collection (e.g., cleansing, wound left open or closed);
xi. Number of attempts per animal per day (include total number of attempts needed for all work if requesting multiple procedures (e.g., remote tagging and biopsy) on same animal on the same day);
xii. The names of the personnel who will conduct the sampling; and
xiii. Sample preservation and analysis.

g. Non-intrusive sampling (e.g., behavioral observations via focal follows and ground surveys, scat collection, passive acoustic monitoring and recording, photo-ID, photogrammetry, remote video monitoring, underwater photography); include i-vi, below, in your activity description:
i. Approach, sampling methods, and platform type;
ii. Minimum and maximum approach distance (specify different distances for each deployment method);
iii. Are researchers within sight of animals or not (e.g., from a blind)?
iv. Frequency of observations/sampling;
v. Duration of observations/sampling per day; and
vi. If conducting underwater photography/videography, specify the method (e.g., snorkeling, underwater pole cam, or divers using typical gear or rebreathers) and number of people in the water at a given time, including the safety diver/snorkeler.

h. Testing methodologies on captive-held animals; include i-iii, below, in your activity description:
i. A description of the methodologies and equipment to be used;
ii. Duration and times of testing and data analyses; and
iii. Methods used to decondition the animals that will be released to the wild after testing.

i. Other procedures/activities; list each additional procedure/activity and provide a detailed description of each, including all appropriate mitigation measures (note, we might contact you with follow-up clarification of methodologies), novel procedures, and any procedures involving active acoustic or hearing studies).

21. **For each procedure/activity**, provide the information in a-j, below, including the maximum number of animals of each species expected to be taken by the procedure annually, broken down by sex and age class; the number of takes per animal per year; and an estimate of the number of animals of the study species that might be incidentally harassed (i.e.,# of non-target animals of your study species that might be harassed by your activities). Also, include the time-periods and specific locations of the takes. This information may be provided in table format such as:

a. Species	b. Procedure/ Activity	c.Level A or Level B Harassment*or other Take**	d.Age Class(see question 23, below)	e. Sex	f.Max. # Animals Per Year	g.Max. # Takes Per Animal Per Year	h.Max. # non-target conspecifics incidentally harassed	i.Time-period	j. Location

*** Level A harassment** means any act of pursuit, torment, or annoyance which has the potential to injure a marine mammal or marine mammal stock in the wild. **Level B harassment** means any act of pursuit, torment, or annoyance which has the potential to disturb a marine mammal or marine mammal stock in the wild by causing disruption of behavioral patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering.

****Take**, as defined by the MMPA means to harass, hunt, capture, or kill, or attempt to harass, hunt, capture, or kill any marine mammal.

22. Will any female-pup/calf/cub pairs be targeted for any of the proposed research activities? If so, describe how you would minimize impacts on pups/calves/cubs and associated females during each of those activities.

23. Define each age class listed in your response to question 21(d), above, for each species (i.e., list the range of months or years (or mass for otters) constituting each age class); provide the minimum age (or mass) that animals will be targeted for take activities; and indicate whether females with calves/pups/cubs less than that minimum age will be targeted for take activities?

24. Describe the precautions that will be taken to minimize the likelihood that harassment of non-target individuals of the study species will occur and the actions that will be taken should harassment occur.

25. Explain how you determined that your methods involve the least possible degree of pain and suffering and why there are no feasible alternative methods to obtain the desired data or results.

26. Provide: a) an estimate of the possible number of unintentional deaths or serious injuries that might result from your research activities; b) the number of unintentional and intentional (via euthanasia for humane purposes if an animal is seriously injured) deaths or serious injuries you seek approval for annually; c) the steps you will take to reduce the likelihood of deaths or injuries; and d) if euthanasia might occur, provide the method of euthanasia (e.g., gunshot, drug, etc.) and who would conduct the euthanasia procedure.

27. In the event of a death, will a necropsy be conducted on the animal?
☐ NO ☐ YES

28. If a female animal accompanied by calf/pup/cub(s) dies during research activities, specify the disposition of the associated calf/pup/cub(s).

29. If biological samples are to be collected or received domestically, provide responses to a through j, below, for each individual animal per species. This information, or part of the information, may be provided in table format such as the table below. (Note: if your **only** proposed activity is to transfer dead marine mammal specimens for purposes of public display or scientific research, complete application Form 3-200-87).

a. Species	**b. ID #**	**c. Sex**	**d. Source (Wild or Captive/ Live or Dead)**	**e. Birth Date or age class**	**f. Type of Samples (blood, tissue, DNA)**	**g. Number of animals sampled annually**	**h. Number of times each animal will be sampled annually**	**i. Packaging and Preservation of samples**	**j. Use/ Disposition of Samples**

k. Provide a detailed description of the source of the specimens, including the circumstances under which the animals were/will be taken. For example, this might include the following sources:
   i. Animals stranded alive or dead;
   ii. Animals killed during legal subsistence harvests;
   iii. Animals killed incidental to legal commercial fishing operations;
   iv. Samples from other authorized researchers or collections;
   v. Soft or hard parts that are sloughed, excreted, or discharged naturally;
   vi. Samples that will be/were intrusively collected from captive-held animals;
   vii. Samples that will /were collected from wild animals.

l. If collecting samples from live animals, describe how the samples were/will be collected, including animal handling and sample collection protocols.

m. For samples received domestically from U.S. permitted researchers, include the researcher's name, affiliation, and permit number under which samples will be/were collected.

(Note: if samples are to be imported, you must answer question 12, above).

30. Provide a list of all personnel that will be involved in the project, identifying each as either a principal investigator or co-investigator, their project duties/responsibilities, and a brief description or CV that demonstrates their experience and expertise to perform their designated duties, including knowledge of the marine mammal species that is/are the subject of this application.

31. Describe how you will collaborate or coordinate with other researchers in your study area. Who are they? Explain how this will occur and how it will minimize negative impacts on the species. For example, will it involve sharing resources, samples or data; timing surveys to minimize disturbance, etc.?

32. If you intend to conduct research on animals in a captive-holding facility such as a zoo or aquarium, provide documentation showing that the facility(ies) has authorized you to conduct your proposed activities.

33. Animal Welfare Act (AWA) Compliance (for research on live animals only): AWA requirements apply to all research facilities, which include institutions, organizations, or people that use or intend to use LIVE animals in research, tests, or experiments; AND, that receive funds under a grant, award, loan, or contract from a department, agency, or instrumentality of the U.S. for the purpose of carrying out research, tests, or experiments, or acquires or transports the animals in commerce. **Provide the following documentation:**

    a. Registration under the AWA as a research facility:
        i. Attach a copy of your APHIS certificate of registration as a research facility, or for Federal facilities, a letter from your Institutional Officer that you are compliant with applicable requirements for scientific research under the AWA; **OR**
        ii. If your facility does/will not conduct activities requiring registration under the AWA, attach a letter from APHIS confirming that registration is not required.
    b. Institutional Animal Care and Use Committee (IACUC) documentation: If your facility is registered as a research facility under the AWA or is a Federal research facility (see a.i), attach the applicable IACUC documentation from the list in i-iii, below. Please note that all activities that involve an invasive procedure, harm, or materially alter the behavior of an animal under study, even if the activities are carried out in the field, are subject to IACUC review and approval. See (AWA regulations and standards for definition/explanation of covered research activities.):
        i. Attach a copy of your final protocols with the IACUC signed approval; **OR**
        ii. Attach a copy of your proposed protocols to be reviewed by your IACUC along with an explanation as to how and when the protocols will be reviewed (Note: A copy of your final signed protocols and certification will be required prior to permit issuance.); **OR**
        iii. Attach the IACUC determination that your research activities are not subject to IACUC review and approval.
    c. If your facility is not registered as a research facility under the AWA, please provide an explanation of how your take activities are reviewed and monitored to assure that the proposed takes are humane (i.e., using the method that involves the least possible degree of pain and suffering).

PART IV.

FOR RESCUE, REHABILITATION, AND/OR RELEASE OF STRANDED[2] MARINE MAMMALS (☑ CHECK IF NOT APPLICABLE)

Marine mammals may be captured from the wild by duly authorized U.S. Fish and Wildlife Service personnel or **authorized cooperators** for the protection or welfare of the marine mammal or for the protection of public health and welfare and held at cooperating authorized facilities. This section of the application is for those parties interested in applying for a letter of authorization (LOA) under MMPA Sections 109(h)/112(c). Parties interested in rescue, rehabilitation, and release activities involving ESA-listed marine mammals would also use this section of the application to apply for an accompanying ESA permit for enhancement of propagation or survival of the species OR to apply as a "sub-permittee" working under the authority of an ESA permit held by different organization or agency. Authorized "sub-permittees" would be responsible for coordinating their activities with the designated ESA permit-holder (i.e., "Permittee") and would be required to comply with the conditions of that permit. Each authorized party's MMPA LOA will document the ESA permit number associated with that LOA, whether the party is a sub-permittee or the Permittee on the ESA permit.

The MMPA LOA or, for ESA-listed species, the combined MMPA LOA and ESA permit would provide authorization for individuals or institutions to work as "cooperators" for the purpose(s) of rescue, rehabilitation, and/or release of stranded marine mammals. Marine mammal rescues are dangerous activities that require trained staff, specialized equipment, and clear communication among stranding partners. The U.S. Fish and Wildlife Service provides opportunities for different levels of involvement for approved cooperators: verifiers, rescuers, transporters, critical care facilities, and rehabilitation/holding facilities. These roles are defined in question 37, below.

34. Are you/your organization currently conducting research activities with marine mammals?

☐ **NO** ☐ **YES; provide the permit number under which you are conducting research____________.**

35. What type of authorization are you requesting (check all that apply)?

☐ LOA under MMPA Sections 109(h)/112(c)

☐ ESA permit for enhancement of propagation or survival of the species

☐ Sub-permittee under ESA permit #__________________.

36. What type of stranding event are you requesting to respond as a cooperator for a U.S. Fish and Wildlife Service marine mammal rescue, rehabilitation, and release program?

☐ OIL SPILL EVENTS

☐ OTHER CONTAMINANT SPILL EVENTS; SPECIFY TYPES________________________________.

☐ OTHER STRANDING EVENTS

[2] The term, "stranding," as defined by the MMPA means an event in the wild in which: (A) a marine mammal is dead and is on a beach or shore of the United States or in the waters under the jurisdiction of the United States (including any navigable waters); OR (B) a marine mammal is alive and is on a beach or shore of the United States and unable to return to the water, on a beach or shore of the United States and, although able to return to the water, is in need of apparent medical attention, or in the waters under the jurisdiction of the United States (including any navigable waters), but is unable to return to its natural habitat under its own power or without assistance.

37. Indicate at which level(s) of responsibility the cooperator will participate (Check all that apply, and respond to the questions below).

☐ **VERIFIER:** The role of verifiers is limited to answering requests to provide physical verification of the condition of reported live, distressed animals and communicating the location and status of an animal to the appropriate person(s), including the rescue program coordinator and, if so directed, the nearest approved rescue facility. In most cases verifiers are required to stay with the animal until an approved rescue and transport team arrives. No physical interaction with animals is authorized under this designation. Verifiers may handle animals only under the guidance of an onsite designated rescue team(s).

a. Describe your organization's experience in verifying the condition of reported live, distressed or injured animals of each species requested (e.g., years of experience, number of responses, etc.).

b. Describe the qualifications of each of your staff who would be serving as a verifier in your organization that demonstrates their ability to verify the condition of reported, live, distressed animals of each species requested (including any work and/or volunteer experience that describes where, with what authorized organization, approximate number of hours, approximate number of verifications, and other relevant experience). Resumes, curriculum vitae (CV), and other supporting documents may be used to describe qualifications, including experience with the marine mammal species (or another similar marine mammal species) that is/are the subject of this application.

c. List and describe any specialized training that your staff have completed to perform this duty, including where and when the training occurred, which organization provided the training, types of training, and other relevant information.

d. Describe numbers and types of:

a) vehicles (cars, trucks, boats, etc.) that will be used to travel to/from locations of reported, live, distressed animals;

b) communications devices that will be used to communicate with rescue responders (phones, radios, etc.); and;

c) any other related equipment.

e. Provide a statement that you will be available to respond to reports of live, distressed animals of the subject species when needed.

☐ **RESCUER**: Rescuers respond to reports of injured and/or distressed animals and can initiate hands-on rescue and transport efforts as needed. This level of involvement requires substantial expertise and training in species-specific rescue techniques. Rescuers must meet U.S Department of Agriculture (USDA) standards for Humane Handling, Care, Treatment, and Transportation of Marine Mammals when rescuing live animals.

a. Describe your organization's experience in rescuing distressed or injured animals of each species requested (e.g., years of experience, number of rescues, etc.).

b. Describe the qualifications of each of your staff who would be serving as a rescuer in your organization that demonstrates their ability to rescue distressed animals of the subject species (including any work and/or volunteer experience that describes where, with what authorized organization, approximate number of hours, approximate number of rescues, and other relevant experience). Resumes, CVs, and other supporting documents may be used to describe qualifications, including experience with the marine mammal species (or another similar marine mammal species) that is/are the subject of this application.

c. List and describe any specialized training that your staff have completed to perform this duty, including where and when the training occurred, which organization provided the training, types of training, and other relevant information.

d. Describe how you meet or exceed USDA standards. Include a description of the number and types of:
   i. vehicles (cars, trucks, boats, etc.) that will be used to support the rescue of distressed animals;
   ii. rescue equipment (nets, stretchers, etc.) that will be used for rescues;
   iii. communications devices that will be used during rescues (phones, radios, etc.); and
   iv. any other related equipment.

e. Describe your methods of capture of the species of interest, including:
   i. Methods of restraint and holding, including dimensions/type of holding container, if used;
   ii. Minimum number of personnel participating in captures at any given time;
   iii. Precautions you will take to avoid separating female-calf/pup/cub pairs, and protocol in the event they are separated, including disposition of the separated calf/pup/cub; and
   iv. Precautions you will take to minimize incidental harassment of non-target animals of the target species.

f. Provide a statement that you will be available to respond to reports of live, distressed animals when needed.

☐ **TRANSPORTER:** Transporters respond to reports of injured and/or distressed animals and initiate transport

efforts as directed. This level of involvement requires substantial expertise and training in the species-specific transport methodology, as well as, the necessary equipment and trained staff to accompany and move the animals to or between approved critical care and/or rehabilitation/holding facilities. Transporters must meet U.S Department of Agriculture (USDA) standards for Humane Handling, Care, Treatment, and Transportation of Marine Mammals when transporting live animals. Transports must also be consistent with Animal Welfare Act requirements for transportation and USFWS transport regulations.

a. Describe your organization's experience in transporting animals of each species requested (e.g., years of experience, number of transports, etc.).

b. Describe the qualifications of each of your staff in your organization who would be accompanying animals during transport, demonstrating their ability to transport, accompany, and support animals of the subject species (including any work and/or volunteer experience that describes where, with what authorized organization, approximate number of hours, approximate number of transports, and other relevant experience). Resumes, CVs, and other supporting documents may be used to describe qualifications, including experience with the marine mammal species (or another similar marine mammal species) that is/are the subject of this application.

c. List and describe any specialized training that your staff have completed to perform this duty, including where and when the training occurred, which organization provided the training, types of training, and other relevant information.

d. Describe how you meet or exceed USDA standards:

   i. Include a description of the number and types of: a) vehicles (trucks, boats, airplanes, etc.) that you will use to transport animals of the subject species; shipping containers that will be used to transport the animals (including type, construction, dimensions, and weight); other equipment that will be used in the transport of the animals (foam pads, water sprayers, stretchers, etc.); communications devices that will be used during transports (phones, radios, etc.); and any other related equipment.
   ii. Describe how the subject animals will be cared for during transport, including the number of attending staff and a description of the arrangements for watering or otherwise caring for the animals during transport.

e. Provide a statement that you will be available to transport animals of the requested species when needed.

☐ **CRITICAL CARE FACILITY**: These facilities hold and medically treat sick and/or injured animals whose lives would be jeopardized if care were not provided. These facilities have the species-specific equipment, experience and credentials necessary to rescue, stabilize, rehabilitate and release animals. These facilities may also provide long-term care, as needed, for generally healthy animals awaiting release, or they may provide long-term care for those individuals designated as “non-releasable”. Critical care facilities must meet or exceed USDA standards for Humane Handling, Care, Treatment, and Transportation of Marine Mammals when maintaining, treating, and holding live animals.

a. Describe your organization’s experience in maintaining, holding, and caring for distressed or injured animals of each species requested (e.g., years of experience, number of animals held, etc.).

b. Describe the qualifications of each of the staff in your organization who would be caring for, handling, and maintaining animals of the subject species (including any work and/or volunteer experience that describes where, with what authorized organization, approximate number of hours, approximate number of animals, and other relevant experience). Resumes, CVs, and other supporting documents may be used to describe qualifications, including experience with the marine mammal species (or another similar marine mammal species) that is/are the subject of this application.

c. For authorization as a critical care facility, you must have a qualified, critical care veterinarian. Provide the name of the person assigned this role and describe his/her qualifications, including a CV or resume that demonstrates his/her ability to perform this role.

d. Describe how you meet or exceed USDA standards. Include a description of:
   i. critical care and holding areas, including descriptions of holding tanks and haul-out areas. The description should include photographs, drawings, and/or diagrams illustrating the area(s) and facility (or facilities) where animals of the subject species will be held. When describing holding tanks, include dimensions (tank length, width, depth, water volume); describe pumps and filtration systems in tanks (including type and capacity and other relevant information); describe lifting apparatus; describe water heaters (including degree to which tanks can be heated); describe water source and type (and ability to use freshwater, saltwater and/or both); and any other relevant features.
   ii. The maximum number of animals of the subject species that can be housed at your facility.
   iii. The current distribution and number of animals of the subject species by holding tank at your facility (include sex, age (if known), time in captivity, age/size class, calves/pups/cubs, etc.).
   iv. All deaths of the subject species at your facility within the past five years and the steps taken to prevent them.

e. Describe quarantine plans, including location and time-frame.

f. Provide a copy of i) your USDA Animal and Plant Health Inspection Service (APHIS) Animal Welfare Act (AWA) license; and ii) your most recent APHIS inspection report.

g. Provide a statement that you will be available to maintain, care for, and house animals of the subject species when needed, including round the clock veterinary care.

☐ **REHABILITATION/HOLDING FACILITY:** These facilities provide routine husbandry for generally healthy

animals that require a minimum of specialized treatments. These facilities may provide long-term care, as needed, for generally healthy animals awaiting release, or they may provide long-term care for those individuals designated as non-releasable. Holding facilities must meet USDA standards for Humane Handling, Care, Treatment, and Transportation of Marine Mammals when holding live animals.

a. Describe your organization's experience in maintaining and holding animals of each species requested (e.g., years of experience, number of animals held, etc.).

b. Describe the qualifications of each of the staff in your organization who would be caring for, handling, and maintaining animals of the subject species (including any work and/or volunteer experience that describes where, with what authorized organization, approximate number of hours, approximate number of animals, and other relevant experience). Resumes, CVs, and other supporting documents may be used to describe qualifications, including experience with the marine mammal species (or another similar marine mammal species) that is/are the subject of this application.

c. For authorization as a holding facility, you must have a qualified veterinarian. Provide the name of the person assigned this role and describe his/her qualifications, including a CV or resume that demonstrates his/her ability to perform this role.

d. Describe how you meet or exceed USDA standards. Include a description of:
   i. holding areas, including descriptions of holding tanks and haul-out areas. The description should include photographs, drawings, and/or diagrams illustrating the area(s) and facility (or facilities) where animals of the subject species will be held. When describing holding tanks, include dimensions (tank length, width, depth, water volume); describe pumps and filtration systems in tanks (including type and capacity and other relevant information); describe lifting apparatus; describe water heaters (including degree to which tanks can be heated); describe water source and type (and ability to use freshwater, saltwater and/or both); and any other relevant features.
   ii. The maximum number of animals of the subject species that can be housed at your facility.
   iii. The current distribution and number of animals of the subject species by holding tank at your facility (include sex, age (if known), time in captivity, age/size class, calves/pups/cubs, etc.).
   iv. All deaths of the subject species at your facility within the past five years and the steps taken to prevent them.

e. Describe your facility's quarantine plans, including location and time-frame;

f. Provide a copy of i) your USDA Animal and Plant Health Inspection Service (APHIS) Animal Welfare Act (AWA) license; and ii) your most recent APHIS inspection report.

g. Provide a statement that you will be available to maintain and house animals of the subject species when needed.

h. Are you seeking approval to display the animals while holding and maintaining them for rehabilitation purposes?
___**NO** ___**YES**; in i-iii, below, provide information to show that:

i. The facility is open to the general public without limitations or restrictions (other than by the charging of an admission fee);
ii. The facility offers a program for education or conservation purposes that is based on professionally recognized standards of the public display community; and
iii. Such display will not interfere with attainment of the objectives of the permitted/authorized activity.

PART V.

FOR MMPA ENHANCEMENT OF SURVIVAL OR RECOVERY OF A SPECIES OR STOCK

Note: This section of the application should not be completed unless you are specifically requesting MMPA Enhancement activities (e.g., this section is not intended for those parties requesting to conduct rescue, rehabilitation, and release activities for marine mammals).

38. Provide information to show that your proposed activities are likely to contribute significantly to maintaining or increasing the distribution or population numbers necessary to ensure the survival or recovery of the species or stock in the wild.

39. Provide information to show that your proposed activities are consistent with any conservation or recovery plan for the species or stock, or, if no plans are available, that the activity is consistent with the actions required to enhance the survival or recovery of the species or stock and that would be addressed in a conservation or recovery plan. For activities that involve captive maintenance of live animals:

a. Provide an explanation on the benefit of removing animals from the wild into captivity; and
b. Include a description of plans in place for returning animals and any offspring to the wild.

(Note: You must also provide the information requested in question 14, above.)

SECTION E.

If requesting renewal or amendment of your current permit, provide an update of any activity that has occurred under the permit since your last report.

Since our last annual report (which included all activities in calendar year 2017), we have captured and flipper tagged 5 female southern sea otters. Four of these were adult and one was a subadult. Two of these sea otters (1 adult and 1 subadult) received radio transmitters. All 5 animals were captured off the Monterey Peninsula in March 2018.

PART I

5. Provide a copy of any other applicable Federal, local, or state permissions (e.g., National Wildlife Refuge Special Use Permit, NOAA National Marine Sanctuary permit, etc.) required to conduct your proposed work, OR indicate whether you have applied for, secured, or will apply for such permissions (please provide contact information).

Not Applicable

6. Is/are the species or population stock(s) for which you applying listed under the U.S. Endangered Species Act (ESA), a species proposed for listing, or a candidate species?

Yes.

a. Attach a justification for taking an ESA-listed species, and explain why your proposed activities are not appropriate for a similar non-ESA-listed species;

The USGS is the agency responsible for research on sea otters, a DOI trust species. Sea otters are protected under the MMPA and in some areas of their range (including California) are listed as threatened under the ESA. The USGS sea otter research project was initially established in the 1970's, has been operating continuously since then (through changes in personnel and in agencies where the project has resided), and is the primary agency responsible for conducting sea otter research. For some controlled studies (e.g, laboratory research), mink or ferrets may be used as a surrogate species for sea otters; however, for studies of sea otter populations in the wild, there is no suitable surrogate.

b. Describe both the short- and long-term anticipated effects of each of your activities alone or cumulatively on the behavior and physiology of the target animals and critical habitat or proposed critical habitat for the species.

Based on the results of our past research, we are able to gain some insight into both physiological and behavioral effects of capture/sampling/tagging/surgery over the short and long term. As far as substantial physiological effects that may affect survival rates, our data suggest that these are not substantial enough so as to be measurable: this assertion is based on a number of published demographic analyses (Siniff and Ralls, 1991; Tinker et al 2006; Tinker et al 2008) that estimate survival rates from radio tagged animals, and then compare these vital rate estimates with independent estimates derived from the age structure of the death assemblage, as well as the expected vital rates given the observed rate of population growth. Based on these comparisons, it appears that the radio-tagged cohorts exhibit the same age/sex specific survival and reproductive rates as the population as a whole (or if there is a difference, it is too small to be measurable).

As far as more subtle behavioral and physiological impacts of our activities, we have two data sets that we can use to infer that there are indeed significant, though transient, effects: 1) observational data on time-activity budgets and foraging behavior, and 2) data from archival time-depth recorders on dive behavior and core body temperature. In both cases, the data suggest a range of individual responses: at one extreme, some animals return to a regular pattern of feeding activity and core body temperature ranges within 24 hours of the surgical implantation of instruments (Fig 1 A,B), while at the other extreme some animals may exhibit slightly reduced (or occasionally elevated) temperatures and reduced diving activity for 2-7days post-surgery (Fig 1 C,D). Most animals fall somewhere between these two extremes: for animals that do exhibit a prolonged recovery time, the short term effects include reduced activity, elevated temperature and likely some mass-loss due to reduced feeding. The longer term effects for such animals are more difficult to gauge: because these animals return to typical activity levels within 1-2 weeks, and (in the case of females) go on to successfully gestate and raise pups (M. Staedler, 2010, Master's Thesis, UCSC), we infer that any long term effects of our activities fall within the normal range of physiological challenges dealt with by wild sea otters. Examination of the surgical sites on study animals that die (for reasons unrelated to our activities, e.g. shark bite or disease infections) and undergo thorough necropsies suggest that the surgical wounds are entirely healed within 30 days of the surgical intervention (Dr. M. Miller, CDFW, Dr. M. Murray, MBA, pers. comm.). In a very small number of cases, there may be some entanglement of one or both of the implanted instruments within the omentum (a tissue layer within the abdominal cavity): this condition is very rarely life threatening to the animal, although it may in some cases affect the ability of the omentum to respond to other "problems" within the abdominal cavity, such as intestinal parasites that burrow through the intestinal wall. Such conditions are very infrequent, having been observed in only a handful of cases out of many hundreds of animals that have undergone this procedure.

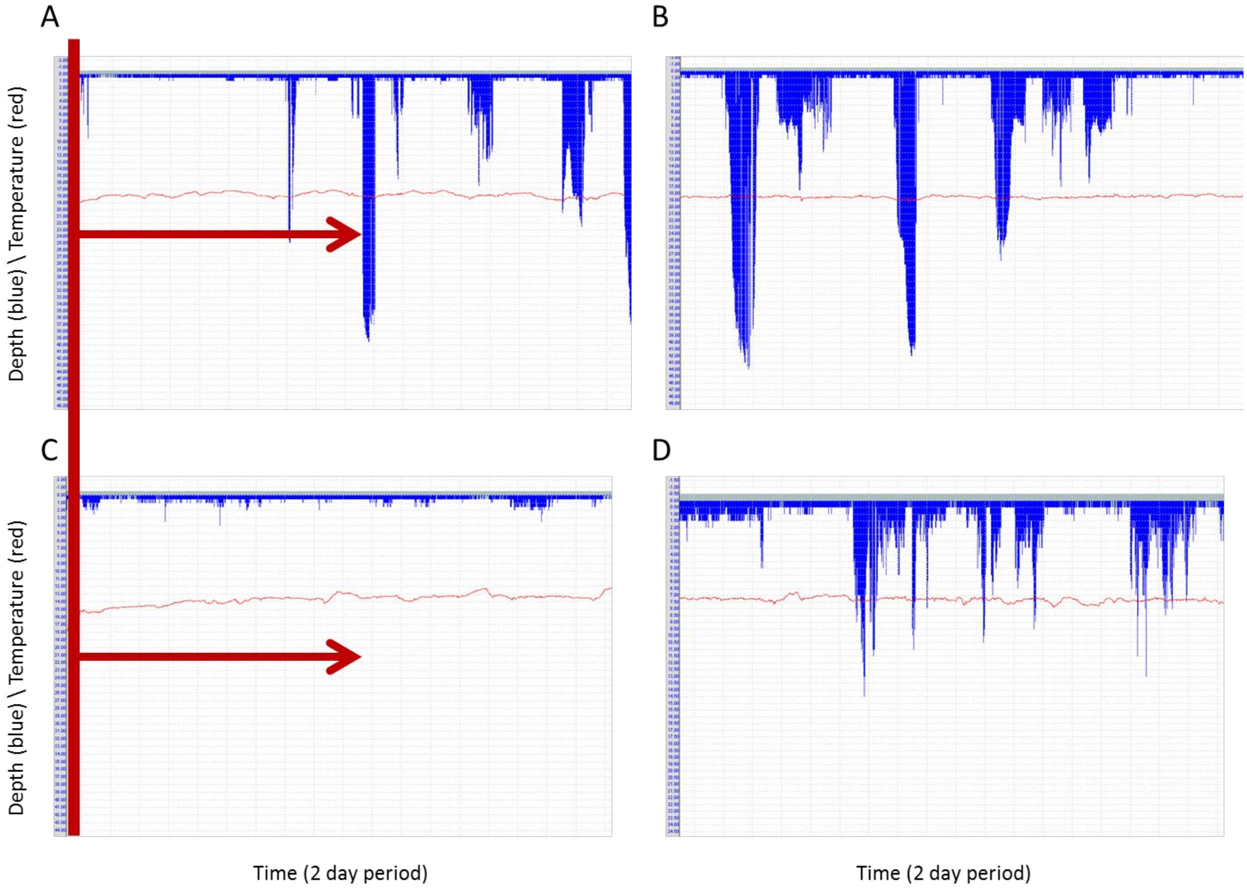


Figure 1. *Time-depth-temperature profiles from two adult female sea otters captured in Monterey. In all 4 plots, dive profiles are shown in blue (vertical depth axis scale is held constant, with surface at top and 45m depth at bottom), temperature profiles are shown in red (vertical temperature axis scale is held constant), and the horizontal axis is time (48 hours are shown in all cases). Two 48-hour periods are shown for female 1 at top and two 48-hour periods are shown for female 2 at bottom. The plots on the left hand side (A, C) depict diving activity and temperature immediately after surgical implantation of the instrument (the dark red vertical band shows time of implanting, the horizontal red arrow shows a 24 hour period after surgery). The plots on the right hand side depict diving activity and temperature on typical days 2 months later for each animal. Female 1 resumes normal diving activity and temperature within 24 hours (compare A to B), while female 2 exhibits reduced diving activity and slightly depressed temperature for the first 48 hours after surgery (compare C to D).*

c. Describe how the animals will react to your actions and the consequences of those reactions.

See attached USGS ASC IACUC-approved SOP: Sea Otter Capture, Chemical Immobilization, Routine Sampling, and Routine Surgery for more details on the following activities.

Capture of sea otters results in potential disturbance to animals that are in close proximity to captured animals but are not captured themselves. Tangle nets offer the greatest potential disturbance of the capture methods used while dip-netting and diver captures generally cause less disturbance. Because most captures will be by divers and median or average group sizes are between 1-3 otters, a reasonable approximation of disturbance would be 50-200% of the number actually captured. However, disturbance is of very short duration, less than 30 minutes, as the transport vessel arrives and departs quickly from the capture location. This incidental disturbance is similar to that caused by other boats (recreational, fishing, etc) operating in close proximity to sea otters. Precautions to minimize incidental disturbance will be to vacate the capture location as quickly as possible, avoid targeting large groups if possible, approach and depart via routes that do not interfere with foraging or traveling otters or other resting groups, and to stop using an area for a day or longer after a few disturbances have occurred (whether from successful captures or unsuccessful attempts). If harassment does occur, we will vacate the area as soon as possible to allow the otters to return to their normal behaviors.

Individual sea otters have variable reactions to our capture attempts. Most attempt to flee, though some individuals put up very little resistance. Their reaction to our capture attempts undoubtedly causes some degree of stress, as with any animal capture. We go to great lengths to minimize stress and handling time with these animals (see section D, below) by using experienced personnel and custom designed equipment, and our decades of research demonstrates that the reactions of the captured sea otters are acute/temporary, and once released, normal behavior is resumed, usually within 24 hours.

d. Identify how you would mitigate any potential negative effects.

It starts with our approach to capturing sea otters. The boat does not approach the animals directly and keeps a suitable distance away from the target otters. Disturbing or causing the otters to react is counterproductive to our entire capture effort, so we ensure that the otters are kept unaware of our presence until the moment of capture. Using divers whenever possible further prevents negative reactions from otters, since they are not becoming entangled in a net or being chased by a boat. The divers use highly advanced technology by employing oxygen rebreathers which vent no bubbles and are completely silent. These are the same rebreathers that are used by combat divers like NAVY SEALs in order to remain completely undetected. Not only does this technology increase our effectiveness, but being undetected by the otters also means that they do not react to our presence until absolutely necessary (at the moment of capture).

Once captured, the otters are transferred to a specialized holding box that has been custom designed to minimize stress and maximize comfort of the captured otter. The boxes are made of plywood and provide a dark space, which calms the animal. The boxes also have numerous holes in the sides and bottom which allows for air ventilation. These holes also permit the box to be partially submerged in the water, allowing the otter to thermoregulate using the cold sea water to combat any increase in body temperature that might result during the capture process. In our decades of experience employing this technique, the otters are remarkably calm once in the holding box. The box also has a PVC "false bottom" that allows any debris or fouling material such as feces to pass through the bottom and exit the box, keeping the inside of the box clean of any substance that could potentially foul the otter's coat.

Any negative effects of animal processing (collecting morphometric data, blood or tissue samples, and/or surgical implantation of instruments) are minimized by sedating the sea otter, so it is unaware of the procedures that are occurring. The sedative also has a minor short-term memory loss component associated with it, which will help the animal to forget the encounter once released, reducing any sort of stress that could possibly occur after release.

7. Do you plan to conduct activities with MARINE MAMMALS IN THEIR NATURAL ENVIRONMENT (i.e., in the wild) where "non-target" marine mammal and ESA-listed species occur in the United States? ("Non-target" species are species that are not the subject of your activities.)

a. A list of all non-target marine mammals and ESA-listed species that might occur in your project area or might be affect by your activities

<u>Marbled Murrelet (Brachyramphus marmoratus)</u>
<u>California Least Tern (Sterna antillarum browni)</u>
We anticipate that our activities will have no effect on marbled murrelets or least terns. In our experience, they are rarely encountered during our sea otter captures. We represent no greater risk to either of these species than any other boat on the water. In fact, we are less likely to affect murrelets because we are often traveling at slow speeds close to shore, where we are unlikely to encounter this species. The risk of encounter is even lower for least terns since they spend more time in flight and less time on the surface of the water than murrelets. Most likely, an encounter with least terns would involve the terns flying over or near our boats, resulting in no discernable impact to either terns or murrelets.

<u>Leatherback Sea Turtle (*Dermochelys coriacea*)</u>
<u>Olive Ridley Sea Turtle (*Lepidochelys olivacea*)</u>
We anticipate little to no impact on these chelonid species. Though leatherbacks do occur occasionally in these waters, they are almost always found in an open ocean/pelagic environment. We conduct our research in nearshore, shallow environments and are unlikely to ever encounter a sea turtle. Though tangle nets may represent a hazard to sea turtles in areas with dense turtle populations, we only set our nets in shallow waters, usually in or around kelp, where sea turtles are unlikely to occur. Although the scenario of a sea turtle getting caught in an otter tangle net is extremely unlikely, our protocols set forth in section 12(b) above, combined with our proposed amendment to the tangle net protocols in 12(b) insures that we will be able to quickly recognize and respond to an event where a turtle or any other non-target species becomes entangled in a net. Additionally, tangle nets are rarely used in California. Our

primary capture method of using diver-operated Wilson Traps and dip nets, due to their precise and selective nature, presents no risk to either species of sea turtle.

Steelhead (Oncorhynchus (=Salmo) mykiss)

Steelhead do occur in coastal waters off Central California, but our operations represent little to no risk to this species. Our primary capture methods (diver-operated Wilson Trap and dip netting) represent zero risk to this species. Tangle nets could potentially represent a risk to larger steelhead if the nets are set near creeks where steelhead run. As mentioned above, tangle nets are rarely used in California and thus any interaction with this gear and steelhead is unlikely. However, we would take care not to set nets in close proximity to the mouths of known steelhead streams. Also, our protocols set forth in section 12(b) above, combined with our proposed amendment to the tangle net protocols in 12(b) insures that we will be able to quickly recognize and respond to an event where any large non-target species becomes entangled in a net. In many years of otter captures in California, not a single steelhead has ever been caught in a tangle net.

Blue Whale (Balaenoptera musculus)
Humpback Whale (Megaptera novaeangliae)
Southern Resident Killer Whale (Orcinus orca)

These three species of cetaceans do occur off the Central California coast, with the humpback whale being the most common of the three. Realistically, our sea otter capture techniques do not present a risk to blue, humpback, or killer whales. These whales are usually encountered off shore or in deeper water, while we are almost always working in very shallow, nearshore waters. Though we do see humpback whales occasionally, they are usually far away from any kelp forests or locations where we are trying to catch sea otters. With that said, we always exercise common sense when deploying a tangle net. If there is a high amount of cetacean activity in the vicinity, we would choose not to deploy a tangle net in that area. In the extremely unlikely event that one of these whales were to become entangled in a net, the procedures (including the proposed amendment) set forth in Section 12(b) insure that we would be able to notice the problem immediately (perhaps even before it happens) and respond quickly to either prevent entanglement or free the entangled animal.

Other marine mammal species that reside in our study area and could be impacted include: California sea lion (*Zalophus californianus*), Harbor Seal (*Phoca vitulina*), Bottlenose Dolphin (*Tursiops truncates*), Harbor Porpoise (*Phocoena phocoena*), Risso's Dolphin (*Grampus griseus*), and Gray Whale (*Eschrichtius robustus*).

These species, though not Federally-listed, are marine mammals that do occur in the vicinity of the Central California coast where we will be working. The impact of our operations on these species should be minimal. As previously mentioned, the use of diver-operated Wilson Traps and dip nets, by their precise and selective nature, present no risk to these marine mammals or any other species mentioned in this section. The use of tangle nets, however, does pose a slightly elevated risk to these smaller marine mammals. We minimize the risk by rarely using tangle nets in California. Still, there are rare times when tangle nets must be deployed. In such instances we take care not to deploy the nets if there is an abundance of non-target marine mammals (such as seals, sea lions, or dolphins) in the area. In the unlikely event that a non-target marine mammal should become entangled in the net, the protocols set forth in the tangle net methodology section 12(b), combined with the amendment proposed in section 12(b), insures that we will be able to notice and respond quickly if a non-target marine mammal were to become entangled in a net. Researchers would do everything in their power (including cutting the tangle net) to release the animal as quickly as possible. Given the low frequency of tangle net usage compared to our other techniques (Wilson Traps and Dip Nets), combined with the precautions taken when using tangle nets, we expect that the likelihood of our sea otter capture operations impacting other marine mammal species would be very low.

b. The maximum number of animals of each non-target marine mammal and ESA-listed species (# per species) that might be harassed by your activities, the precautions that you will take to minimize the likelihood that harassment will occur, and the actions that you will take should harassment occur;

In general, we do not expect to harass Federally-listed species or non-target marine mammals, so the maximum expected number of animals harassed from part 7a = 0 for all species listed. The techniques of capturing otters by diver-operated Wilson Trap and dip net are very selective, precise, and accurate. This allows us to avoid harassing any species but the specific otters that we are targeting. The use of boats to conduct our work presents no greater risk to non-target species than any other boat on the water. In fact, our boats probably present less risk because we are diligent observers of marine life, we are usually moving at very slow speeds, and we generally work in shallow nearshore waters. When using tangle nets, the risk of harassment of non-target species increases, but remains extremely low.

Despite the low risk of harassment, we still take numerous precautions when using tangle nets. The deployment of nets is made under due consideration of predicted weather conditions: nets will not be set during periods of weather or sea state that may preclude their tending. Unlike in Alaska, tangle nets will very rarely be used in California, and only under circumstances where their use will (in the best judgment of the permit holder) represent a significantly lower risk of disturbance to sea otters and/or other marine mammal species. In cases where tangle nets are deployed we will also deploy 2 shore-based observers to monitor the nets and the entire vicinity of the nets (with a high-powered spotting scope) in order to detect the presence of non-target marine mammals. If there is detection of a non-target marine mammal, the nearby tending skiff will be called in to either pull the net or else remain beside the net until the marine mammals have left the area entirely. Additionally, at the time of net deployment, buoy-type floats will be attached to the float line at regular intervals (~10m apart) to increase the visibility of the float line and thus the likelihood that a shore-based observer with a telescope who was scanning that float line would be able to detect if even a small section of the net became pulled under water, signaling a possible entanglement. In such a case the tending skiff would be called in immediately to investigate (and release an entangled animal if that were the case). We believe both of the previously mentioned advanced monitoring techniques nearly eliminates the likelihood for unintended harassment of non-target marine mammals. At the very least, these protocols enable us to respond quickly and effectively, should unintended harassment occur.

c. The maximum number of animals of each non-target marine mammal and ESA-listed species (# per species) that might be taken (e.g., killed, injured, feeding activities disrupted, etc.) by your activities, your precautions to minimize the likelihood that take will occur, and your actions should take occur.

We do not expect to take any of the non-target marine mammal or ESA-listed species from #7a, so the expected maximum number = 0

10. Are you requesting to CAPTURE LIVE marine mammals in the wild? (i.e., for research, public display, or MMPA enhancement)

YES.

a. A description of the manner in which the animal will be captured, type of gear used, and deployment method (e.g., from shore or boat approach and net deployment).

Individual sea otters will be captured either in tangle nets, underwater diver-held traps (Wilson traps), or hand-held dip nets. All methods are routinely used throughout the range of the sea otter population (U.S., Russia, and Canada). Recapture of individuals will most likely be by underwater diver-held traps.

<u>Diver-operated Wilson Traps</u>

Our primary capture method involves using diver-operated traps to capture resting sea otters. Shore spotters with high-powered spotting scopes relay information about target animals to the dive crew. Divers work in pairs and each diver has a trap with a capacity for one adult sea otter, 2 juveniles, or a mother/pup pair. Otters must be resting (preferably sleeping) for this method to be successful. Divers use closed-circuit oxygen rebreathers and electric propulsion vehicles to maneuver the traps underneath the floating sea otters and engulf them with a net bag, which is closed by a purse line. The divers keep the animal and trap on the surface until the transport vessel arrives and the otters can be transferred to a sliding-lid capture box. Our research group has captured >600 sea otters in California, and >1000 sea otters in California, Alaska, Washington, Canada, and Russia combined, using diver operated Wilson traps with no trap-related mortalities. This method is highly selective, with zero chance for taking non-target species. Furthermore, this method allows us to target specific individuals, minimizing disturbance or harassment to non-target individuals.

<u>Tangle Nets</u>

Tangle nets are surface floating, un-weighted nets set in near shore waters in the vicinity of sea otters. Nets are typically 100 m long by 5 m deep (stretch mesh of about 22 cm), but may be modified to capture in shallow water. Each tangle net consists of stretch mesh hung between a positively-buoyant float line and a slightly negatively buoyant led line, and are suspended between large float buoys at each end which are anchored in place (ensuring sufficient anchor-line scope to avoid dragging the buoys below the surface under any tide or current condition). Nets are set out by a tending skiff and then monitored by the skiff and/or shore-based observers (see amendment request below). When one or more otters become entangled in the net, the skiff returns and extracts the otter(s), transferring them to capture boxes for transport to the processing site. The deployment of nets is made under due consideration of predicted weather conditions: nets will not be set during periods of weather or sea state that may preclude their tending. Unlike in Alaska, tangle nets are very rarely be used in California, and only under circumstances where their use will (in the best judgment of the permit holder) represent a significantly lower risk of disturbance to sea otters and/or other marine mammal species.

In an effort to minimize the chances of entanglements or by-catch of non-target species: 1) two shore-based observers with telescopes (instead of just one) will monitor a deployed net, with one observer continuously scanning the float line of the net in order to detect entanglements, and the second observer scanning the entire vicinity around the net for any marine mammal activity. In the event that any non-target marine mammals are detected in the area by that second observer, the tending skiff will be called in to either pull the net or else remain beside the net until the marine mammals have left the vicinity entirely; 2) at the time of net deployment, buoy-type floats will be attached to the float line at regular intervals (~10m apart) to increase the visibility of the float line and thus the likelihood that a shore-based observer with a telescope who was scanning that float line would be able to detect if even a small section of the net became pulled under water, signaling a possible entanglement. In such a case the tending skiff would be called in immediately to investigate (and release an entangled animal if that were the case).

Dip Nets

Dip-netting is a procedure where sea otters are dipped out of the water with a large fish-landing net. Open-water capture takes place from the bow of a small skiff, with one net handler and a vessel operator. This method is usually generally used to capture young animals. USGS personnel have been involved in the capture of >250 sea otters using dip-nets with no dip-net-related mortalities.

b. Methods of restraint and holding, including dimensions/type of holding container, if used;
The sea otters are transferred directly from the Wilson Trap, Tangle Net, or Dip Net, to a specially designed “otter box.” These boxes have been customized over many decades of sea otter capture and handling, and represent the best possible temporary holding container for sea otters. Box materials, dimensions, and accessories have been designed and approved by both sea otter biologists and sea otter veterinarians with decades of experience in handling and transporting wild sea otters.

The boxes are made of marine grade plywood with an epoxy coating to protect the otters and the box itself. The epoxy also creates a smooth surface on the interior, and makes the boxes easy to clean. Wood is a desirable material because it is strong and sturdy, but still soft enough that the most uncooperative otters can chew it without damaging their teeth. The interior dimensions of the boxes are 36”L x 17”W x 22”H, providing more than enough room for an adult male sea otter, or a female and large pup. The box features a sliding plywood lid. By design, the walls and lid create a dark interior, which is believed by veterinarians and animal care experts, to have a calming effect on the animals inside. Our decades of field experience with these boxes has shown that the otters appear to be very calm once inside the box.

All 4 sides, and the bottom panel of the box feature 5/8” holes drilled at multiple levels for adequate ventilation. These holes serve another purpose though. The box may be floated in the ocean, alongside the boat, at any time. The holes allow water to enter the box, so that the otter can float inside the box. The cold seawater helps the otter thermoregulate, and helps to prevent any overheating that might potentially occur as a physiological response to the capture process.

Inside the box, a “false bottom” is installed. This is a PVC grate that allows refuse or materials such as feces to pass through the grate and exit via the bottom of the box, eliminating any chance of the material fouling the otter’s fur. This keeps the interior of the box clean and tidy. Boxes also have canine “chew toys” (the kind you get at your local pet store) installed for the otter that like to chew. Chewing on a chew toy decreases the likelihood of the otters chewing on the wood box, while also giving them a distraction and enrichment experience while inside the box.

When otters need to be physically restrained (e.g. when being injective with the sedative) the procedure is done so in the safety of the otter box. A “stuff sack,” which is a very soft cushion similar to a pillow but covered with a tough cordura exterior, is used to gently block the otter’s head and shoulders while the vet administers the injection into the hindquarters. The process only takes a few seconds, and the otter usually uses the stuff sack as a chew toy.

c. The holding time required prior to transport or release of the animal;
Captured individuals will be transported from the capture location to the handling location in holding boxes that provide adequate ventilation. Ice or cold water will be provided as needed to keep the animals cool. Transport time will be kept to a minimum by co-locating capture vessels and handling/processing platforms. All animals will be released at or as near to their location of capture as is possible. Efforts will be made to process and release sea otters within 2 hrs of capture.

d. Number and roles of personnel participating in the captures;
The number of personnel involved in sea otter captures in California varies greatly, depending on the daily capture effort and/or the total duration of the capture event. However, it is not uncommon for the total number of personnel to number between 20-30 individuals. Roles are as follows:

Diver: 2 per boat, if multiple boats are used, there could be 4 or 6 divers working in teams of 2. The divers locate the target otters and perform the capture. They secure the otter in box, take local samples (water) and data (GPS, time, etc.), and transport the captured otter to the veterinary team on shore. This could involve dropping the otter off at the Monterey Bay Aquarium davit or a hoist on a pier, or transferring the otter shore via a beach-loading by inflatable boat, or transferring the otter to a larger vessel where the vet crew is operating. Depending on workload, the divers may also assist in animal processing and tagging. Diver's typically perform the releases of the otters as well.

Boat Operator: Assist with all the same duties as the divers, except the actual diving. Must be experienced otter spotter and skilled boat operator. Provides directions to the divers during the "capture run." Drives the boat and ensures the safety of the animals and the crew.

Boat Tender/Deckhand: Assist the Boat Operator in all tasks requiring assistance. Help secure and transport otters. Performs necessary duties of deckhand, including prepping and stowing gear, and assisting divers in and out of the water.

Shore Spotter: Usually in a team of 2, stationed on shore with binoculars and high-powered spotting scopes. Shore spotters are usually the ones that first locate the target otter, often using VHF radio telemetry (in the case of recaptures). Shore spotters relay location information and directions to boat crews and divers. During the capture run, shore spotters are able to assist the boat operator and tender by being and extra set of eyes (with a spotting scope). They can alert the boat crew or dive team to any changes in the status of the target otter, or if any hazards present themselves. The shore spotters also diligently monitor tangle nets, on the rare occasion that they are deployed.

Shore Team Coordinator: Orchestrates and oversees all shore-based operations from the time that the otters come ashore, to the time it is released or given back to the boat crews.

Veterinarian: Ultimately responsible for the well-being of the sea otters. Any judgement calls related to the health or safety of the animals are made by the vet in charge. The vet team performs surgeries, administers drugs, monitors anesthetized otters, and performs all examinations. Any data collected or procedures done on an otter once it reaches the vet team is supervised by the veterinarian.

Vet Tech: Assists the veterinarian and any and all duties required. May take samples/swabs from sea otters.

Blood Tech: Assists veterinarian and vet tech. Primarily responsible for obtaining, processing, and storing blood samples taken from the sea otters.

Data Tech: Responsible for recording a host of biological, morphological, and physiological data on every animal that is processed. Some examples of data collected: length, weight, tail length, paw width, age estimate, tooth condition, overall body condition, dental map of entire mouth, photos of mouth/teeth, baculum length, amount drugs or medication administered, reactions of animal (if any), details and timing of all procedures, etc.

e. Duration of restraint/holding from capture to release; and

As stated in (c) above, every effort is made to not exceed 2 hrs from time of capture to time of release. The otters are not physically restrained for this entire time. Most of the time is spent in the safety and relative comfort of the otter box, or anesthetized.

f. The number of non-target individual animals of the target species that will be incidentally harassed during capture activities, and precautions you will take to minimize incidental harassment of non-target animals;

During the most recent 5-year period the average number of sea otters incidentally harassed during capture activities was 54 per year (with a high of 93 in 2016). We expect the number to not be above 100 in any year. The majority of these incidental harassment cases occur during diving captures using Wilson traps and are almost always due to the habit of sea otters resting in groups or rafts. When capturing target otters in a raft, nearby otters may be disturbed. We attempt to minimize the disturbance or incidental harassment of non-target otters. The rebreather diver techniques described previously are the best way to minimize incidental harassment because the divers remain undetected for the entire dive, until the moment of capture. Our captures are most successful when we are completely undetected, so minimizing incidental harassment is inherent to the success of our work. When possible, we avoid targeting an animal when it's in a very large group of otters. The odds of successful capture decrease when the target is resting in a large group. Sometimes this cannot be avoided, however, most capture attempts are on solo animals, animals in pairs, or otherwise small rafts.

g. If capturing females with calves/pups/cubs, describe:

Sea otter females and pups generally rest together, with the pup either on top of the mother, or alongside the mother, often in contact with one another. Since our studies often aim to answer questions pertaining to demography, population biology, and survival, we don't explicitly avoid capturing mothers and pups, as this would introduce a substantial bias. However, we also don't specifically target mothers and pups. Also, females may be captured without a pup, but recaptured later on, with a pup. In general, we will avoid capturing a female with a newborn pup because of the small size of the pup. However, it is not always possible to see the small pup prior to a capture, and even if the pup is observed, it can be very difficult to determine age of the pup under difficult viewing or ocean conditions. As a result we are requesting the ability to capture all age classes or sea otters, but with the caveat that in situations where a newborn pup is easily visible, we will likely not attempt to capture that mother-pup pair. When capturing mothers and pups, they will either be (a) captured together in the same Wilson Trap or (b) be captured simultaneously in 2 different Wilson Traps, depending on how far apart the mother and pup are from one another. It is possible that, if a diver made an error or had an equipment/trap malfunction, a female may be captured without her pup, or a pup without it's mother. Although such an occurrence is rare, it has happened in the past. In such a situation, the captured animal (either mother or pup) is immediately released from the Wilson Trap, allowing them to reunite with each other. We have never had an issue with the mother and pup not reuniting on their own in a situation such as this.

i. How calves/pup/cubs will be held;

Immediately after capture, the mother and pup will be transferred to a holding box, like all captured otters. In general, the mother and pup are placed in the same holding box. However, certain instances may dictate that holding the mother and pup in separate boxes would be the most prudent course of action. For example, if the pup is quite small and the mother is not showing clear maternal behavior towards the pup, it might be safer to keep the pup in its own box, to prevent any possibility of incidental injury to the pup. At the other end of the spectrum, sometimes very large pups are as big as the mother. In this case, the mom and pup might be placed into separate holding boxes so that both otters can have sufficient space. Mothers and pups, regardless of age or pup size, are always released together to reduce the chance of separation.

ii. Which procedures will be conducted on them;

Females with pup may be subjected to all the normal veterinary procedures that any captured sea otter would normally be subjected to. This includes surgery for the implantation of VHF radio transmitters. In addition, sterile oxytocin (20 units/ml) may be injected intramuscularly to facilitate milk letdown in lactating females. Oxytocin, a hormone produced by the hypothalamus stimulates contraction of the smooth muscle of the mammary glands to release milk. We will only attempt to collect milk samples from females with dependent pups, no pregnant females or females without pups will be given oxytocin.

In general, the size of the pup dictates what samples, tags, or procedures are performed on the pup. The pup must weigh at least 20 lbs to qualify for and instrument implantation. Additionally, only pups greater 11 lbs will be flipper tagged. Pups weighing less than 6 lbs will not be PIT-tagged. Pups of all sizes may have morphometric data (e.g. length, weight) and demographic data (e.g. sex) collected.

iii. The duration of time the pair will be separated; and

Given that our estimated time from capture to release is 2 hrs, it's fair to say that the max time that a mother and pup would be separated is for this entire 2hr duration. In practice, the timing is much shorter, since the mother and pup usually share a holding box. If the mother is anesthetized for surgery, the pup will only be separated from the mom during the surgical procedure. This is typically <1 hr.

iv. Procedures used to reunite the pair, and if they do not reunite, explain the disposition of the calf/pup/cub.

We take all the necessary precautions to ensure that a separation of mother and pup does not occur. In fact, due to our precautions and the strong mothering instinct of female sea otters, a separation would be considered an extremely rare event. Therefore, reuniting a mother-pup pair is something that is almost never required in our work. As one of our precautions, we observe the behavior of the mother and pup together, in the holding box, to make sure their behavior is still indicative of a bonded pair (e.g. mother holding or grooming pup) before releasing them. We will also employ a “soft release” technique with moms and smaller pups. This method involves submerging the box on its side, about halfway in the water at the side of the boat, then slowly opening the door of the box. The otters will usually calmly swim out of the box.

However, in the extremely unlikely event of a separation, this would probably occur by virtue of the mother immediately leaving the holding box upon release, and leaving the pup behind in the box. This is only a concern with a small pup since larger pups are capable of swimming on their own and catching up to their mother. If a small pup is left behind in the box, the persons conducting the release will immediately remove the pup from the box and place it in the water to float. Releases are always done with the boat placed upwind so that the mother can smell her pup if she initially leaves without it. This will aid her in relocating her pup when she inevitably returns to look for it. In an extreme situation where the mother doesn’t immediately return for the pup, the pup is held high in the air so that the sound of the pup’s call can travel a greater distance, enticing the mother to return and retrieve her pup. If this still does not work, the pup will be left at the site of release, and the boat will back away. Our shore spotters will monitor the pup through a high-powered spotting scope to see if the mother returns to claim the pup. Should these attempts fail and the mother does not return, the pup will be rescued by the boat crew, and brought back into veterinary team. At the discretion of the lead veterinarian, if it is deemed that the pup has truly been abandoned, the pup may be raised in captivity at the Monterey Bay Aquarium as part of their surrogacy program, and could be released back into the wild once mature. We have never had to resort to this final step in many hundreds of wild sea otter captures.

h. A description of the use of drugs during capture, including:

i. Name of each drug/chemical used, its dosage rate (ml/kg), method of administration (IV, IM, SQ, topical and whether remotely-deployed IM), and purpose of the drug;

Chemical Immobilization / Anesthesia:

Approved personnel will immobilize sea otters following slightly modified procedures to those described in Monson et al. 2001, Chemical anesthesia of northern sea otters (Enhydra lutris): results from past field studies. In this paper, the benzodiazepine, diazepam, is one of the induction agents. Diazepam is well known for its inconsistent and unpredictable absorption when administered intramuscularly. An aqueous solution of a closely related drug, midazolam, is substituted milligram for milligram. As a result, expression of the effects of fentanyl, muscle rigidity and potential seizures is prevented.

Captured sea otters will be anesthetized in sliding-lid holding boxes using a combination of fentanyl citrate and midazolam hydrochloride (F/M) and reversed with naltrexone hydrochloride (N). This combination has been used successfully for the immobilization of over 1500 sea otters of both sexes, all age classes, and in varying states of physiological and/or pathological condition. There have been no anesthetic-related mortalities associated with this immobilization protocol in field settings to date. Fentanyl/Midazolam produces smooth inductions with little or no muscle tremors or convulsions while Naltrexone provides rapid, complete reversal of the opiate, fentanyl with no risk of re-induction. The holding boxes prevent premature escape of sedated animals while providing the captured otter a calm, quiet space. The observational access provided by these capture boxes facilitate close monitoring of sea otters as induction proceeds, as well as assurance that complete reversal, including return to normal body temperature, has occurred prior to release.

Intramuscular injections of fentanyl and midazolam are administered separately with different syringes at dose rates adjusted to the purpose of handling. Darting is not used because otters are usually in the water and the risks of drowning or 'struck and loss' are too great. We use target dose rates of 0.33 mg/kg of fentanyl and 0.11 mg/kg of midazolam for surgical procedures, and 0.22 mg/kg fentanyl and 0.07 mg/kg of midazolam for non-surgical, biological sampling procedures as recommended by Monson et al. (2001). If anesthesia is not complete after approximately 15 minutes, additional fentanyl may be given. If 2-times the initial fentanyl dose is incrementally reached, and sedation is still not complete, the antagonist is given and the animal released without further handling (this is rarely observed). In the event of excessive tremors or convulsions, additional intravenous midazolam may be administered. Inhalant agents, such as isoflurane or sevoflurane, may be used as needed should anesthetic depth be deemed inadequate by the attending veterinarian. Also, based on the best judgment of the attending veterinarian, local anesthetics such as bupivacaine may be applied when potentially painful procedures are considered in the case of animals that are immobilized with lower does or when anesthetic depth be deemed inadequate.

The reversal agent Naltrexone is administered intramuscularly, at a dose equal to 2-5 times the fentanyl dose, immediately following handling. In addition, sterile oxytocin (20 units/ml) may be injected intramuscularly to facilitate milk letdown in lactating females. Oxytocin, a hormone produced by the hypothalamus stimulates contraction of the smooth muscle of the mammary glands to release milk. We will only attempt to collect milk samples from females with dependent pups, no pregnant females or females without pups will be given oxytocin.

ii. Duration of drug and required holding time;

There are essentially two different doses of fentanyl/midazolam that are utilized. The lower dose is used for immobilization/restraint and provides approximately 60-90 minutes of sedation time. The higher dose level is the one utilized as an anesthetic dose and provides both immobilization and analgesia. The former will last for approximately 60 minutes with an additional 60 minutes of "restraint time" similar to that encountered at lower dosages.

There is an 8-12 minute lag time between the intramuscular administration of the drugs and effect. Both drugs have a reversal agent, however, typically only the fentanyl is reversed. Naltrexone is a direct antagonist requiring approximately 1-4 minutes to reverse the effects of fentanyl. It is metabolized more slowly than fentanyl, therefore re-sedation is not a problem. There is no post-reversal holding period required. Once animals are reversed, they are capable of being returned to the water and begin swimming immediately and foraging occurs shortly thereafter.

iii. The names of the personnel who would administer the drugs;

Michael Murray (DVM), Christine Fiorello (DVM), Nancy Anderson (DVM), Lesanna Lahner (DVM), Raymond Wack (DVM), Heather Harris (DVM), Christine Kreuder-Johnson (DVM), Cara Field (DVM), Shawn Johnson (DVM), Claire Simeone (DVM), and Dave Casper (DVM).

iv. Provisions to minimize adverse reaction(s), including the use of appropriate drug reversals;

Drug doses are adjusted based on the physical appearance of the otter, information obtained by interviewing the capture team, and the anticipated level of chemical immobilization required. The lowest dose possible is administer. Reversal agents for fentanyl and midazolam, naltrexone and flumazenil, respectively, are always on hand in case of emergency. The naltrexone is always drawn into a syringe and ready for administration before induction agents are administered. Traditional emergency preparedness is practiced, with emergency drugs, endotracheal intubation equipment/supplies, and provision for oxygen administration on hand. In case of instability which cannot be readily managed, reversal agents are administered either intravenously or intramuscularly depending upon the situation.

v. Procedures to be used to minimize the chance that drugged animals will escape or enter the water prior to complete immobilization; and

Darting is not used because otters are usually in the water and the risks of drowning or 'struck and loss' are too great. Animals are drugged in the confines of a holding box (previously described in this permit application). As such, the otters are not near any water and cannot escape.

vi. Measures to be taken to ensure that the animal is fully recovered prior to release.

Naltrexone is the reversal drug that is administered. Naltrexone has a rapid onset and the initial "first response" time is typically noted within one minute. Monitoring by an experienced team member continues until reversal is complete and the animal is deemed releasable by the attending veterinarian. Monitoring and evaluation of the reversal is performed in the confines of the holding box. The otter is only returned to the boats/release crew once the vet has determined that it is fully reversed and ready for release. Typically, at least 10 additional minutes will pass from the time of transfer to the release crew to the actual release, since travel back to the site of capture is often required.

i. What emergency procedures would be employed (e.g., drugs, bagging, CPR, etc.) in the event that an animal's condition starts deteriorating during capture activities?

In case of emergency, traditional medical response protocols will be followed. If the otter has received immobilization drugs, their effects will be reversed with the appropriate antagonists, typically naltrexone and flumazenil. Additional emergency procedures, if needed, will follow the ABCD's of emergency medicine. A: establish airway. In sea otters this will involve the provision of supplemental oxygen. The otter may require tracheal intubation and intermittent positive pressure ventilation. B: breathing. Respiratory rates, effort, and effectiveness will be monitored. If need be, assisted ventilation with pure oxygen or ambient air will be provided. Pulse oximetry and/or blood gas monitoring will be done to ensure efficacy of respiration. C: circulatory. In cases of actual, suspected, or impending circulatory collapse, intravenous catheterization of the external jugular vein may be necessary. Supplemental fluids can then be administered to provide circulatory support. D: drugs. A spectrum of emergency drugs will be on hand in a well-stocked emergency kit. These drugs will be administered based upon the data obtained and interpreted by the attending veterinarian.

PART III

17. Explain how the proposed research meets the MMPA definition of "bona fide research," i.e., scientific research on marine mammals, the results of which: (A) are likely to be accepted for publication in a referenced scientific journal; (B) are likely to contribute to the basic knowledge of marine mammal biology or ecology; or (C) are likely to identify, evaluate, or resolve conservation problems.

The research conducted under this permit will result in creation of manuscripts likely to be accepted in scholarly/peer-reviewed journals, based on our past research activities (see citation list of peer-reviewed publications based on research conducted under prior versions of this permit). This research will also be beneficial to evaluation and remediation of anthropogenic factors that may contribute to sea otter mortality and thus prevent recovery of this stock. Additionally, data and samples collected under this permit will add to the basic knowledge of sea otter biology and ecology, allowing better informed management and conservation decisions.

18. Provide a detailed description of the proposed project. You may attach a formal research proposal, provided it includes all the requested information, including:

a. Objectives and hypotheses and associated methodology;

b. Background information discussing relevant published literature on the subject of your proposal, with citations;

c. An explanation of how this study is different from, builds upon, or duplicates past research;

d. An explanation of how you determined your sample size/take numbers (e.g., based on previous encounter rates or abundance estimates for the study area). If appropriate for your study, include a power analysis or other sample size estimation to show whether the sample size is sufficient to provide statistically significant or otherwise robust results appropriate for your study;

e. If proposing novel procedures, include a discussion on results from pilot studies or studies on other species, if available; and
f. Disposition of animals or remaining specimen material once your project is complete.

Pleased see the enclosed documents for the proposals for 3 studies that are currently in progress.

In brief, the Monterey NSF Predator Diversity Study is investigating the impact of a sudden loss of a meso-predator (sea stars) on kelp forest community composition, and the the ability of sea otters to mitigate the loss of other predators in the system through behavioral plasticity. The study has the potential to redefine the role of sea otters in kelp forest communities. The results may elucidate the mechanism by which otters "control" urchins/grazers, and will demonstrate why simply having a healthy sea otter population may not be the only requirement for healthy kelp forest ecosystems in California.

The on-going San Nicolas Island Sea Otter Population Monitoring work is a continuation of a multi-decadal survey that monitors the status and growth or decline of a translocated population of sea otters at San Nicolas Island. The US Navy is funding additional monitoring work that involves diet and behavioral observations. The project utilizes a tiered approach, based on the findings of our research. If survey numbers drop below a critical threshold, or if sea otter deaths as a result of US Navy activities are observed, the project would advance to the next tier, and may eventually require the capture, tagging, and intensive monitoring of sea otters at San Nicolas Island.

The Tagging Technology project is described elsewhere in this application, but this joint NASA-USGS venture aims to utilize state-of-the-art technology to finally incorporate GPS data in a sea otter tag, allowing for more accurate and frequent resights of sea otters with much less effort/personnel. Moreover, the tags are being designed to work in a mesh-network, where individual otters will resight each other, via tags that communicate with one another, and offload their data to base stations whenever they are in range. This tagging technology is cutting edge, and will greatly advance our knowledge of sea otter ecology, behavior, movements, and interactions. It will also present a less invasive alternative to studying sea otter behavior.

19. Provide the expected research schedule (clearly specify the proposed start date and end date of your research or field season(s) and overall duration of the project). Include the months of the year and frequency of fieldwork/sampling (e.g., number of times per year). If your research extends beyond five years, or is a continuation of previously authorized research, give information about when the research began and when you expect it to end.

Our research program has been essentially continuous since 1998, and is part of a long-term monitoring and research program mandated and supported by the Federal agency responsible for management of this species. Research is ongoing at sites throughout the sea otter's range in coastal California (see research proposals above), and these (or similar) studies are anticipated to continue throughout the 5-year period covered by the permit. Because of the broad, comparative nature of our research, and the need to obtain representative data from throughout the range (and over all seasons and across years) on all population parameters, sampling may occur at any location within the current range of southern sea otters (see attached map, Figure 2) and at any time of year within the time period covered by the permit.

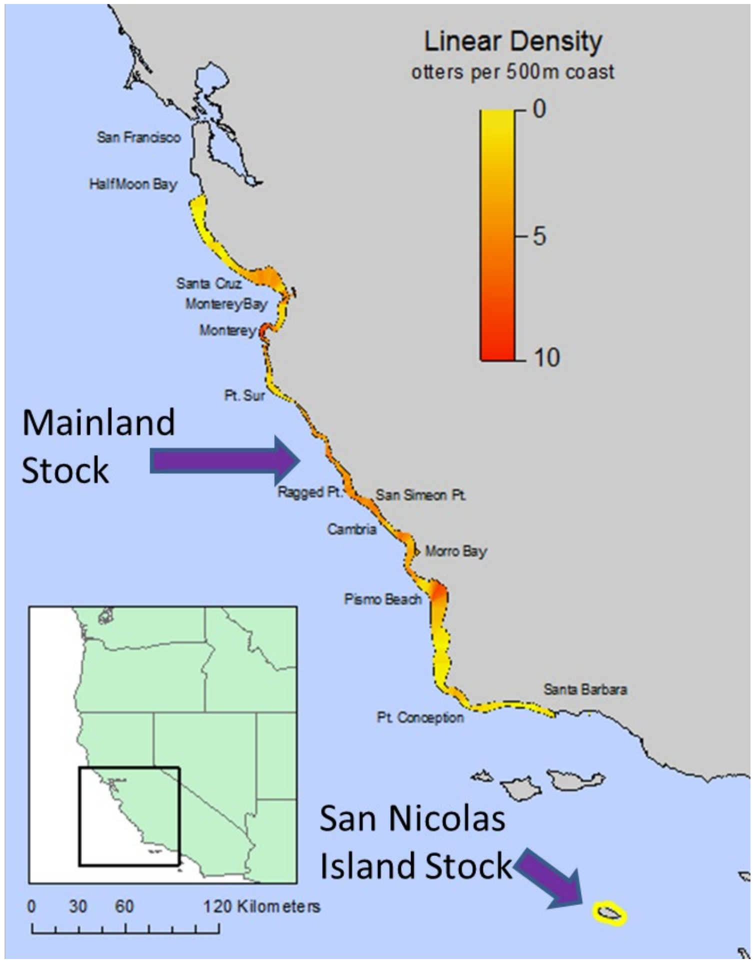


Figure 2. *Range of the Southern sea otter population showing the separation of the two stocks. Sea otter distribution shown as colored band along the coast, with warmer colors corresponding to higher sea otter densities.*

20. Indicate which research procedures/activities you will be conducting that will or might result in **TAKE or HARASSMENT of TARGET species**, and describe each activity in detail, including the information indicated in a-i, below.

Take or harassment of targeted sea otters will occur when sea otters are captured by one of three methods (described in detail in section 12b): tangle nets, underwater diver-held traps (Wilson traps), or hand-held dip nets. All methods are routinely used throughout the range of the sea otter population (U.S., Russia, and Canada). Recapture of individuals will be by underwater diver-held Wilson traps.

Because of the broad, comparative nature of our research, and the need to obtain representative data from throughout the range (and over all seasons and across years) on all population parameters, sampling may occur at any location within the current range of southern sea otters (see attached map, Figure 2) and at any time of year within the time period covered by the permit.

See attached USGS WERC Santa Cruz Field Station IACUC-approved SOP: Sea Otter Capture, Chemical Immobilization, Routine Sampling, and Routine Surgery for more details on capture and sampling methods.

a. Administration of drugs (including emergency drugs and prophylactic antibiotic use) or other substances (e.g., stable isotopes); include i-vii, below, in your activity description:

i. Name of each drug/chemical used, its dosage rate (ml/kg), method of administration (IV, IM, SQ, topical and whether remotely-deployed IM), and purpose of the drug;

Approved personnel will immobilize sea otters following slightly modified procedures to those described in Monson et al. 2001, Chemical anesthesia of northern sea otters (Enhydra lutris): results from past field studies. In this paper, the benzodiazepine, diazepam, is one of the induction agents. Diazepam is well known for its inconsistent and unpredictable absorption when administered intramuscularly. An aqueous solution of a closely related drug, midazolam, is substituted milligram for milligram. As a result, expression of the effects of fentanyl, muscle rigidity and potential seizures is prevented.

Captured sea otters will be anesthetized in sliding-lid holding boxes using a combination of fentanyl citrate and midazolam hydrochloride (F/M) and reversed with naltrexone hydrochloride (N). This combination has been used successfully for the immobilization of over 1500 sea otters of both sexes, all age classes, and in varying states of physiological and/or pathological condition. There have been no anesthetic-related mortalities associated with this immobilization protocol in field settings to date. Fentanyl/Midazolam produces smooth inductions with little or no muscle tremors or convulsions while Naltrexone provides rapid, complete reversal of the opiate, fentanyl with no risk of re-induction. The holding boxes prevent premature escape of sedated animals while providing the captured otter a calm, quiet space. The observational access provided by these capture boxes facilitate close monitoring of sea otters as induction proceeds, as well as assurance that complete reversal, including return to normal body temperature, has occurred prior to release.

Intramuscular injections of fentanyl and midazolam are administered separately with different syringes at dose rates adjusted to the purpose of handling. Darting is not used because otters are usually in the water and the risks of drowning or 'struck and loss' are too great. We use target dose rates of 0.33 mg/kg of fentanyl and 0.11 mg/kg of midazolam for surgical procedures, and 0.22 mg/kg fentanyl and 0.07 mg/kg of midazolam for non-surgical, biological sampling procedures as recommended by Monson et al. (2001). If anesthesia is not complete after approximately 15 minutes, additional fentanyl may be given. If 2-times the initial fentanyl dose is incrementally reached, and sedation is still not complete, the antagonist is given and the animal released without further handling (this is rarely observed). In the event of excessive tremors or convulsions, additional intravenous midazolam may be administered. Inhalant agents, such as isoflurane or sevoflurane, may be used as needed should anesthetic depth be deemed inadequate by the attending veterinarian. Also, based on the best judgment of the attending veterinarian, local anesthetics such as bupivacaine may be applied when potentially painful procedures are considered in the case of animals that are immobilized with lower does or when anesthetic depth be deemed inadequate.

The reversal agent Naltrexone is administered intramuscularly, at a dose equal to 2-5 times the fentanyl dose, immediately following handling. In addition, sterile oxytocin (20 units/ml) may be injected intramuscularly to facilitate milk letdown in lactating females. Oxytocin, a hormone produced by the hypothalamus stimulates contraction of the smooth muscle of the mammary glands to release milk. We will only attempt to collect milk samples from females with dependent pups, no pregnant females or females without pups will be given oxytocin.

ii. Duration of drug and required holding time;

There are essentially two different doses of fentanyl/midazolam that are utilized. The lower dose is used for immobilization/restraint and provides approximately 60-90 minutes of sedation time. The higher dose level is the one utilized as an anesthetic dose and provides both immobilization and analgesia. The former will last for approximately 60 minutes with an additional 60 minutes of “restraint time” similar to that encountered at lower dosages.

There is an 8-12 minute lag time between the intramuscular administration of the drugs and effect. Both drugs have a reversal agent, however, typically only the fentanyl is reversed. Naltrexone is a direct antagonist requiring approximately 1-4 minutes to reverse the effects of fentanyl. It is metabolized more slowly than fentanyl, therefore re-sedation is not a problem. There is no post-reversal holding period required. Once animals are reversed, they are capable of being returned to the water and begin swimming immediately and foraging occurs shortly thereafter.

iii. The names of the personnel who would administer the drugs;

Michael Murray (DVM), Christine Fiorello (DVM), Nancy Anderson (DVM), Lesanna Lahner (DVM), Raymond Wack (DVM), Heather Harris (DVM), Christine Kreuder-Johnson (DVM), Cara Field (DVM), Shawn Johnson (DVM), Claire Simeone (DVM), and Dave Casper (DVM).

iv. A description of specific State requirements regarding who (e.g., attending veterinarians, vet technicians, researchers) may handle and administer certain drugs;

Only attending veterinarians will administer and handle the drugs described here

v. Provisions to minimize adverse reaction(s), including the use of appropriate drug reversals;

Drug doses are adjusted based on the physical appearance of the otter, information obtained by interviewing the capture team, and the anticipated level of chemical immobilization required. The lowest dose possible is administer. Reversal agents for fentanyl and midazolam, naltrexone and flumazenil, respectively, are always on hand in case of emergency. The naltrexone is always drawn into a syringe and ready for administration before induction agents are administered. Traditional emergency preparedness is practiced, with emergency drugs, endotracheal intubation equipment/supplies, and provision for oxygen administration on hand. In case of instability which cannot be readily managed, reversal agents are administered either intravenously or intramuscularly depending upon the situation.

vi. Procedures to be used to minimize the chance that drugged animals will escape prior to complete immobilization; and

Darting is not used because otters are usually in the water and the risks of drowning or 'struck and loss' are too great. Animals are drugged in the confines of a holding box (previously described in this permit application). As such, the otters are not near any water and cannot escape.

vii. Measures to be taken to ensure that the animal is fully recovered prior to release.

Naltrexone is the reversal drug that is administered. Naltrexone has a rapid onset and the initial "first response" time is typically noted within one minute. Monitoring by an experienced team member continues until reversal is complete and the animal is deemed releasable by the attending veterinarian. Monitoring and evaluation of the reversal is performed in the confines of the holding box. The otter is only returned to the boats/release crew once the vet has determined that it is fully reversed and ready for release. Typically, at least 10 additional minutes will pass from the time of transfer to the release crew to the actual release, since travel back to the site of capture is often required.

b. Aerial and vessel surveys (manned); include i-v, below, in your activity description:
i. Type of survey craft and vessel;
ii. Type of survey (e.g., line transect, photogrammetry);
iii. Number of surveys per year;
iv. Minimum and maximum altitude/approach distance; and
v. Duration spent with group or individual per day.

We are not requesting any takes as part of aerial or vessel surveys.

c. Aerial surveys using unmanned aircraft systems (UAS); include i-xii, below, in your activity description:
i. Dimensions, mass, and battery life of UAS;
ii. Will the UAS ever be beyond the line of sight?
iii. Does the device have an auto-return feature should the device fail?
iv. Ground control station description (what it is, where it will be located, e.g., on shore or on vessel, number of stations, and how close the station will be to animals);
v. Spotter roles (e.g., one spotter monitoring the UAS, another for monitoring the ground control station);
vi. Do you have the appropriate FAA permits/authorizations (including pilot licenses)?
vii. Type of survey (e.g., line transect, photogrammetry);
viii. Number of surveys per year;
ix. Minimum and maximum altitude/approach distance;
x. Duration spent with group or individual per day;
xi. The names of the personnel who will pilot the aircraft, and
xii. Mitigation measures you will use to minimize disturbance including specific measures you will use to avoid separating female-calf/pup/cub pairs, and measures to ensure the UAS will not collide or crash into any of the animals.

At this time, we are not requesting takes as part of UAS surveys. We hope to use UAS in the future for a variety of applications, however, we are currently not using UAS at present. If the need arises in the future, we will submit a request for an amendment to our permit.

d. Capture and restraint; if you will be capturing animals, ensure that you have completed question 10, above.

Question 10 has been completed.

e. Instrumentation, Marking, and Tagging (MTI); include i-x, below, in your activity description:
i. The type of MTI (including dimensions and mass);

Flipper Tags
Generally all animals captured > 11 lbs will be visually tagged to prevent repeated sampling of the same individuals. Temple tags, used on the hind flippers, are 45 x 14 x 2 mm, and weigh ~7g. Because long-term tag retention rates are <100% (Ames et al. 1982, 1983) each sea otter may also be marked with a coded, passive transponder chip, implanted subcutaneously in the inner thigh. When flipper-tagging, holes are punched using a sterile leather punch (hole diameter <5mm). Flipper tags have been used extensively in sea otter research and rehabilitation effort without any observed deleterious effects.

In addition, we request the ability to use newer electronic “smart” flipper tags in place of 1 or more of the traditional Temple Tags described above. The smart flipper tags will be of comparable size any weight, but are still being developed and tested. These smart tags will have GPS capability allowing them to “talk” to other tags or base stations when in range. They are solar-powered and may include other additional sensors like an accelerometer, wet/dry switch, pressure sensor, etc. These tags are being developed in a collaboration between USGS and NASA. Concurrent to tag development, different materials and form factors are being tested on captive sea otters at the Monterey Bay Aquarium. These smart tags will be capable of collecting geo-location data and conducting otter-shore communications, and we anticipate that eventually they will replace the implantable VHF transmitters as a less-invasive, primary means of sea otter tracking/monitoring. With the addition of a pressure sensory, these tags may even have the ability to eventually replace TDRs, which could eliminate our need to surgically implant instruments in sea otters at a future date. The form-factor and attachment method are similar to the temple tags, and these smart tags would only be deployed on wild otters once enough testing has been conducted with captive otters to ensure that there is no negative response to these tags.

PIT Tags
Implantation of “passive integrated transponders”, or PIT tags, may be done to facilitate identification in the event of external tag loss. PIT tags have been safely used in multiple species of all sizes, including sea otters, without deleterious effects to survival. 125 MHz tags, approximately 13 x 2mm, will be injected into the left inguinal area using a 12 gauge needle and syringe. Tag, needle, and syringe are gas-sterilized together in a package or come pre-sterilized from the manufacturer (Biomark, Boise, ID). PIT tags are encased in biocompatible glass which protects the electronics while preventing adverse effects to the animal. All captured otters will be scanned prior to initiation of sampling/external tagging for identification and to access prior capture history.

VHF Radio Transmitters
For some aspects of our research, use of electronic signaling tags is necessary. VHF radio transmitters (80 x 22 x 50mm, ~160g, Advanced Telemetry Systems, Isanti, MN) are standard instruments that are currently surgically implanted in sea otters. Radios are potted in a waterproof electrical resin and coated with a USP Class VI material (United States Pharmacopeia, Class VI requires the most stringent testing). Instruments are gas-sterilized

and sealed in surgical steri-peal pouches for storage until used. This procedure has been successfully completed on several hundred sea otters in Alaska and California with very low rates of mortality (< 0.2%).

ii. The maximum number and total mass of MTIs to be attached to/implanted in an animal at a given time;

Each otter will be tagged with unique color/number coded polyethylene "Temple Tags" (livestock ear tags, Temple, TX) in their hind flippers (typically 2 tags per otter [1 per flipper], no more than 4 tags [2 on each flipper]). The minimum total mass of 2 flipper tags would be a combined 14g, with the maximum (4 tags) equaling approximately 28g.

A maximum of 1 VHF radio transmitter will be implanted (total mass ~160g).

iii. The maximum dart penetration depth if MTI is attached via darts;

Not applicable. We do not use darts.

iv. Methods and location of attachment, including minimum approach distance for remote MTI attachment;

Flipper Tags

Flipper tags are attached to the hind flippers in the space (webbing) between the flipper digits. A sterile leather punch (<5mm) is used to punch a hole in the webbing of the flipper, taking care to avoid blood vessels. The plastic or composite tag is threaded through the punched hole and secured with a screw. The screw is embedded within the tag, glued to ensure a stronger hold, and recessed/not exposed in any way. At the discretion of the DVM, two holes may be punched per flipper tag, if deemed appropriate for a more secure attachment. Typically one flipper tag will be applied to each flipper, but occasionally a 3rd or 4th flipper tag may be applied, if additional colors are needed for identification or if traditional Temple Tags are needed to accompany a new electronic flipper tag. No more than 2 flipper tags would be applied per flipper.

Surgical Implantation (VHF) Procedure

VHF transmitters are internally implanted, rather than being externally attached as in many marine mammal species, because 1) sea otters are unable to tolerate external attachments that might compromise their pelage (which is critical for thermoregulation), and 2) attached instruments similar to those used on pinnipeds would compromise their swimming and foraging abilities because of their small size. Furthermore, because of the nature of sea otter grooming activity, they are capable of reaching and removing (or destroying) most existing types of externally-attached tags.

Consistent with sound veterinary surgical practice, abdominal surgery, including implantation of VHF is done with aseptic technique. Modifications of traditional methods are necessary, however, in order to accommodate the need for immediate post-operative return to the wild and preservation of the integrity of the sea otter's pelage due to its importance in thermoregulation. Rather than shaving the fur from the surgical site, the fur overlying the ventral midline is parted with a fine-toothed comb and held in place with a combination of water soluble, sterile surgical lubricating jelly and aqueous 10% solution of povidone-iodine.

Access into the abdominal cavity is through an appropriately sized (6-10 cm) incision through the linea alba. Individually sterilized VHF transmitters are then placed directly into the abdominal cavity. If deemed necessary by the surgeon a solution of diluted antibiotic may be infused into the body cavity prior to closure.

A multi-layer, typically consisting of 4 separate suture lines, linea alba, subcutanesous fat/muscle, subcuticular, and skin, closure is meticulously performed to assure a water-tight seal, as well as to mitigate the potential for dehiscence either due to technique or self-mutilation. A sterile, mono-filament suture which is minimally reactive, provides adequate longevity, yet is absorbed over time is used to close surgical incisions.

In addition to the process described above, additional safeguards are applied during instrument extraction/replacement surgeries. Since surgeries of this nature are more invasive with larger incisions, and greater duration, additional prophylactic measures are taken. In addition to the surgical drapes attached to the skin a secondary sterile draping system is utilized being affixed to either the subcutis or through a specialized sterile wound retractor.

A broad spectrum, extended duration antibiotic is administered in conjunction with surgery. Any significant pathology encountered intra-operatively will be investigated within the limits of the patient's wellbeing. A record of the surgical procedure and associated findings is completed following each procedure.

v. If surgeries for implantable tags are being conducted, specify who will be conducting them, where (in the field or in a facility), and if antibiotic prophylactics will be administered;

Per the previous description in (iv), surgeries to implant VHF radio transmitters will be conducted by authorized veterinarians listed on this permit. The lead veterinarian (usually Dr. Mike Murray of the Monterey Bay Aquarium) supervises other vets and vet techs working under him. For captures in the vicinity of Monterey, surgeries and animal processing will be done in the state-of-the-art Animal Health Lab at the Monterey Bay Aquarium. For captures in more remote locales, surgeries may be conducted in an advanced mobile vet lab (provided by the California Department of Fish & Wildlife) or on a large research vessel in even more remote areas. Prophylactic broad spectrum, extended duration antibiotics will be administered in conjunction with surgery. Refer to (iv) above, the attached SOPs and the veterinary section of question 10 for more information on surgery and antibiotics.

vi. The maximum number of times an animal would be fitted with MTIs in a given year;

Because the flipper tags are made of plastic or some other similar soft material, they may occasionally be chewed off by the sea otters. This is by design, since the soft plastic will not harm the teeth of the otter. We request the ability to recapture an individual to replace flipper tags no more than 3 times per year, with a minimum of at least 3 months between captures of the same individual. There could be a need to collect additional blood or tissue samples, which can be done at the same time as the flipper tag replacement. We will make an attempt to recapture otters equipped with previously implanted time-depth recorders (TDRs) in order to retrieve/explant the TDR instrument so that the archival dive and temperature data can be downloaded. Recapture for TDR explant will take place whenever a sea otter is captured that has an existing TDR from a previous study/permit. We may also recapture an otter to replace the VHF radio if the battery begins to die. Typically, VHF radio batteries last approximately 3 years, for recapture for the purpose of implanting a new VHF radio (if deemed appropriate, for the continuation of the study), would occur once after 2-3 years. Replacement surgery would be performed no more than one time on any given animal.

vii. Will recapture be necessary (if so, how many times will animals be captured annually), would the instrument/tag have a release mechanism, or would the instrument/tag fall off?

Per the previous response (vi), recaptures are necessary for two main reasons. (1) to replace flipper tags that have been chewed off by otters and (2) to explant TDR instruments that were previously implanted under our earlier permits. Because the TDRs and VHF radios are surgically implanted, there is no release mechanism. A third reason, as described above, would be if it is deemed necessary to replace a dying VHF radio with a new radio. This would be a rare occurrence, and would happen only once after at least 2 years from the original radio implantation.

viii. Have the proposed MTIs been used previously on this species?

The Temple Tags, PIT tags, VHF transmitters, and TDRs have been used for many decades on hundreds (or in the case of PIT and flipper tags, thousands) of sea otters, with a very high success rate.

The "smart tag" flipper tags have not yet been deployed on wild sea otters, since they are a cutting-edge technology that is still in development. However, the form factor of these new smart flipper tags will be nearly identical to a Temple Tag, so we don't expect the otters to react to these tags any different than they would the Temple Tags. Regardless, the new tags are undergoing extensive testing on captive sea otters at the Monterey Bay Aquarium, to ensure that they have no adverse impacts on sea otters. Only once we are happy with the results on the captive sea otters, will we deploy this new tag on wild sea otters.

ix. What are the potential adverse effects and the means of monitoring new MTIs for adverse effects?

The only new MTI is the smart flipper tag. Because these tags haven't been used before, and because they are still being developed, it's impossible to know with 100% certainty what adverse effects they might have. However, because the size, weight, and form factor is nearly identical to the existing Temple Tags that have worked remarkably well for decades, we don't anticipate any adverse effects from these new smart flipper tags. As previously mentioned, the new tags are currently undergoing rigorous testing on captive sea otters at the Monterey Bay Aquarium to ensure that they have no adverse impact on the host otters. Once we are satisfied with captive testing, we will deploy the tags on wild sea otters. Given the nature of our research projects, we have observers visually locating the tagged otters multiple times a week (and sometimes daily), which gives us a mechanism for monitoring the well-being of the otters, and any potential adverse effects of the new tags, in real time. If an otter appears to be in severe distress as a result of the tag, we have the capability of deploying a team to capture the otter to help remedy the situation and/or get the otter the treatment it requires from qualified veterinary personnel. The nearshore habits of sea otters allows for a level of direct visual monitoring that is impossible with most other marine mammals.

x. What actions will be taken in the event that the MTI has a significant adverse impact on the animal(s), and what is the method of animal release from the MTI?

If a significant adverse impact is detected by our visual observers, a team of divers can be deployed to recapture the otter in question. Depending on the nature of the impact or distress, it may be remedied on site, or the otter may be brought in to qualified veterinary personnel for examination and/or treatment.

f. Intrusive sampling (e.g., blood, blubber, muscle, skin); include i-xiii below, in your activity description:

Each captured or sampled otter will be given a unique ID number. All specimens collected from an otter will be marked with that unique ID as well as sample type and date of collection. The following table (Table 1) provides details of the types and sizes of samples to be collected as well as storage details. Collection of these samples is standard and was previously permitted under MA672624.

Table 1. Listing of samples and their research uses collected from captured sea otters and/or beach-cast remains. Note that some samples may be collected from both live captured animals and carcasses, while some can only be collected from one or the other. All samples listed have been approved on our previous permit.

TABLE 1. Samples authorized for collection from captured sea otters or beachcast remains

Sample Type	Live/Carcass	Amount Collected	Use	Comments
Blood	Live	5% blood volume (blood volume = 8% BW	Hematology, clinical chemistry, infectious disease monitoring, biomarkers, contaminants	Blood volume "lost" from animal to include collection, loss to hematoma, bleeding from tagging, and surgical bleeding
External swabs (integument, oral cavity, rectum, genital orifice	Live	No volume limitation	Infectious disease (bacterial, fungal, parasitic, viral), contaminants, genetics	
Saliva	Live	0.3 - 1.0 ml	Hormonal assays	
Feces	Live	No limit	Diet assessment, infectious disease (bacterial, fungal, parasitic, viral), contaminants, biotoxin, hormonal assay	From environment
	Live	< 100gm		Collected from rectum
Milk	Live	< 10 ml	Nutritional content, fatty acid analysis, contaminants	May require administration of oxytocin to cause release
Urine	Live	TBD by DVM	infectious disease, toxins, urinalysis, contaminants	Free catch or cystocentesis
Adipose tissue	Both	< 10 gm (live)	Fatty acids, contaminants	May require surgical intervention with appropriate consideration for anesthesia and surgical methodology.
		No limit (dead)		
External pathology (integument, oral cavity, genital orifice)	Both	TBD by DVM	Histopathology, genetics, etiopathogenetic investigation	May require surgical intervention with appropriate consideration for anesthesia and surgical methodology.
Liver biopsies	Both	< 2 gm (live)	Histopathology, toxicology, contaminants, genetics, chemical analysis (ie, Vit A analysis)	May require surgical intervention with appropriate consideration for anesthesia and surgical methodology.
		No limit (dead)		Collected at necropsy
Premolar tooth	Both	1	Cementum aging	First upper premolar, only
Skin plugs	Both	< 2 gm (live)	Genetics	Collected in association with flipper tagging in live animals
Vibrissae	Both	2	Stable isotope	
Baculum	Carcass	1	Morphometrics, stable/radio isotopes	
Tooth	Carcass	No limit (dead)	Cementum aging	
Skull	Carcass	1 or portions	Morphometrics, stable/radio isotopes	
Fur	Both	NMT 1 gm	Hormonal assays, toxins, contaminants	Collected by plucking as not to interfere with thermoregulation.

i. Will sampling be remote or under restraint?
The otters will be anesthetized during sampling.

ii. Will local anesthetics be administered?
A general anesthetic is used.

iii. Type of tissues sampled;

Blood, external swabs (integument, oral cavity, rectum, genital orifice), saliva, feces, milk, urine, adipose tissue, external pathology (integument, oral cavity, genital orifice), liver biopsies, premolar tooth, skin plugs, vibrissae, baculum, tooth, skull, fur

iv. Size or volume of sample (diameter and depth or total volume);

Blood: 5% blood volume (blood volume = 8% BW)
External Swabs: No volume limitation
Saliva: 0.3 - 1.0 ml
Feces: no limit when collected from environment; < 100gm when collected from rectum
Milk: < 10 ml
Urine: TBD by DVM
Adipose Tissue: < 10 gm (live otter); no limit for dead otter
External Pathology: TBD by DVM
Liver Biopsies: < 2 gm (live otter); no limit for dead otter
Premolar Tooth: 1
Skin Plugs: < 2 gm (live otter), collected in associated with flipper tagging the otter
Vibrissae: 2
Baculum: 1 (dead otter only)
Tooth: no limit (dead otter only)
Skull: 1 or portions of whole skull (dead otter only)
Fur: NMT 1 gm

v. Target sampling location on body;

Blood: Intravenous blood draw
External Swabs: Integument, oral cavity, rectum, genital orifice
Saliva: mouth/buccal cavity
Feces: rectum
Milk: teats/mammillary glands
Urine: genital orifice/bladder
Adipose Tissue: body cavity
External Pathology: integument, oral cavity, genital orifice)
Liver Biopsies: liver
Premolar Tooth: mouth/buccal cavity
Skin Plugs: flippers
Vibrissae: muzzle/snout
Baculum: genital region
Tooth: mouth/oral cavity
Skull: head
Fur: exterior/pelt/thoracic

vi. Maximum number of samples per animal per day and per year;

Blood: 5% blood volume (blood volume = 8% BW) per animal per day, max of twice per year
External Swabs: No volume limitation per day, max of twice per year
Saliva: 1.0 ml per day; 2.0ml per year
Feces: no limit when collected from environment; 100gm max per animal per day or 200gm max per animal per year when collected from rectum
Milk: 10 max ml per animal day; 20 ml max per animal per year
Urine: TBD by DVM
Adipose Tissue: 10 gm max per animal per day; 20 gm max per animal per year (live otter); no limit for dead otter
External Pathology: TBD by DVM
Liver Biopsies: 2 gm max per animal per day; 4 gm max per animal per year (live otter); no limit for dead otter
Premolar Tooth: 1 max per animal per day or per year

Skin Plugs: 2 gm max per animal per day; 4 gm max per animal per year (live otter)
Vibrissae: 2 max per animal per day; 4 max per animal per year
Baculum: 1 max ever (dead otter only)
Tooth: no max limit ever (dead otter only)
Skull: 1 or portions of whole skull (dead otter only)
Fur: NMT 1 gm per otter per day; NMT 2 gm per otter per year

vii. Sampling intervals (e.g., for serial blood or biopsy samples);

Samples taken at the time of recapture. As previously state, recaptures, and therefore sampling, will never occur more often than at 3-month intervals, though in practice, most recaptures are annual, or even less frequent.

viii. Collection method and equipment/materials used (e.g., dart fired from rifle, dart depth, sterilization/disinfection);

Refer to Table 1, above. Also, all samples are taken while the animal is "on the table" and anesthetized. The equipment and materials used are all standard medical/veterinary tools that would normally be used in a lab or surgery suite.

ix. If remote, what is the minimum approach distance?

N/A

x. If restrained, describe treatment of site of sample collection (e.g., cleansing, wound left open or closed);

Otters are anesthetized and most samples are minimally invasive (refer to Table 1). For samples that may draw blood (blood sample, premolar sample) the site may bleed and is treated with gauze in the same way you would treat a blood draw in a human.

xi. Number of attempts per animal per day (include total number of attempts needed for all work if requesting multiple procedures (e.g., remote tagging and biopsy) on same animal on the same day);

Because sampling is only done at the time of capture, this is only 1 attempt to collects the necessary samples for each capture/recapture.

xii. The names of the personnel who will conduct the sampling; and

Michael Murray (DVM), Christine Fiorello (DVM), Nancy Anderson (DVM), Lesanna Lahner (DVM), Raymond Wack (DVM), Heather Harris (DVM), Christine Kreuder-Johnson (DVM), Cara Field (DVM), Shawn Johnson (DVM), Claire Simeone (DVM), Dave Casper (DVM), Melissa Miller (DVM), Marissa Young, and Michelle Staedler.

xiii. Sample preservation and analysis.

Blood: Hematology, clinical chemistry, infectious disease monitoring, biomarkers, contaminants
External Swabs: Infectious disease (bacterial, fungal, parasitic, viral), contaminants, genetics
Saliva: Hormonal assays
Feces: Diet assessment, infectious disease (bacterial, fungal, parasitic, viral), contaminants, biotoxin, hormonal assay
Milk: Nutritional content, fatty acid analysis, contaminants
Urine: infectious disease, toxins, urinalysis, contaminants
Adipose Tissue: Fatty acids, contaminants
External Pathology: Histopathology, genetics, etiopathogenetic investigation
Liver Biopsies: Histopathology, toxicology, contaminants, genetics, chemical analysis (ie, Vit A analysis)
Premolar Tooth: Cementum aging
Skin Plugs: Genetics

Vibrissae: Stable Isotopes
Baculum: Morphometrics, stable/radio isotopes
Tooth: Cementum aging
Skull: Morphometrics, stable/radio isotopes
Fur: Hormonal assays, toxins, contaminants

g. Non-intrusive sampling (e.g., behavioral observations via focal follows and ground surveys, scat collection, passive acoustic monitoring and recording, photo-ID, photogrammetry, remote video monitoring, underwater photography); include i-vi, below, in your activity description:

i. Approach, sampling methods, and platform type;

Behavioral observations are typically made from shore using high powered spotting scopes (Questar 50x-80x magnification) and binoculars. Using high powered optics allows us to maintain a large distance between the observer and the sea otters, such that the sea otter never notices the observer. On rare occasion, behavioral observations made be made from a boat or vessel. This method is avoided unless absolutely necessary because it is impossible to use a high powered spotting scope from a vessel and binocular observations are also of poor quality due to wave action and vessel movement. Shore-based observations are far superior and are our method of choice whenever possible. In rare instances where shore access is impossible (e.g. private property situations), vessel observations may be used. We take care to maintain our distance from the otters and to not alter their behavior in any way, as doing so is counterproductive to a behavioral study.

ii. Minimum and maximum approach distance (specify different distances for each deployment method);

It is very difficult to identify a standard minimum approach distance because there is no standard distance that results in disturbance to all sea otters. In certain areas where otters encounter people or vessels regularly (e.g. Monterey, CA), they can be approached very closely (often within 25m or less) without disturbing them. In other areas where otters rarely encounter people or vessels (e.g. Big Sur, CA), sea otters become disturbed from great distances. Therefore, we always use our best judgement when determining approach distances, and do so on a case-by-case basis, taking into account the region and subpopulation of sea otters that we are working with. It is important to note that since our research is predicated on recording and observing natural wild behavior, we take great care to ensure that our presence or activities do not alter wild sea otter behavior in any way. Any alteration of wild behavior would be counterproductive to our research goals, and could result in inaccurate or biased data. Therefore, we have a very strong interest in not disturbing sea otters, and our research team and protocols are clearly designed with that goal in mind. In general, while performing behavioral observations, we rarely see the need to get closer than 100m from the sea otters, so that is a good general guideline for minimum approach distance. On occasion, we may start further away from the sea otter, but the otter may swim closer to us, since it is unaware of our presence, and perhaps even less than 100m away. In this scenario the researchers are instructed to remain low to the ground or use natural cover and minimize movement to reduce the chances of being seen or detected. There is no maximum approach distance for sea otter behavioral observations.

iii. Are researchers within sight of animals or not (e.g., from a blind)?

In general, researchers are not within sight of the animals when conducting behavioral observations. Observers usually remain at a far enough distance so that they cannot be seen by the sea otters. In rare instances where sea otters are habituated or accustomed to the routine presence of people or vessels in close proximity, the otter may see our observers, but they do not react to their presence. If an otter is ever observed to react to the presence of a researcher, action is taken on the part of the researcher to remedy the situation. This is usually done by increasing the distance between the researcher and the sea otter, but may also be accomplished by obscuring the researcher using natural features like large rocks or vegetation. Observers also take care to place themselves downwind of the focal animals, so that the sea otters do not detect the observers by smell.

iv. Frequency of observations/sampling;

During most of our research projects, an effort is made to make daily observations of each study animal. In practice, since locating every animal every day can be difficult, most study animals that remain in the study area are observed an average of 5 times per week.

v. Duration of observations/sampling per day; and

This varies based on the type of data being collected. For simple "resight" data, where the animal's location and general behavior is recorded, an observation might only take a few minutes. If the animal is fast asleep it might take longer in order to see both flipper tags, a requirement for a positive identification of the individual animal. This could take an hour or more. When collecting foraging data, a focal animal is followed for as long as reasonably possible to obtain a quality foraging bout (at least 20 dives, ideally) and may be followed for longer. A focal foraging bout may only last a few minutes, but could last several hours. When collecting observational activity budget data, a focal follow of a single individual sea otter is performed. A resight (behavior and location of the otter) is done every 10 minutes throughout the continuous activity budget. A single activity budget may last for as little as 6 hours, or as many as 24 continuous hours, depending on the goals of the project. It is important to note that the sea otter is never aware that it is being observed during resights, foraging bouts, or activity budgets. The observations are all clandestine. Any detection of the researcher by the sea otter could bias our data and results.

vi. If conducting underwater photography/videography, specify the method (e.g., snorkeling, underwater pole cam, or divers using typical gear or rebreathers) and number of people in the water at a given time, including the safety diver/snorkeler.

No underwater photography or videography is requested in this permit.

h. Testing methodologies on captive-held animals; include i-iii, below, in your activity description:

i. A description of the methodologies and equipment to be used;

None. We are not requesting permission to do this under our permit. We are collaborators on a separate permit with the Monterey Bay Aquarium that deals with testing methodologies on captive-held animals.

ii. Duration and times of testing and data analyses; and

N/A per above.

iii. Methods used to decondition the animals that will be released to the wild after testing.

N/A. Note that although we are currently testing new smart flipper tag technology on captive otters at the Monterey Bay Aquarium, the testing falls under the conditions of a separate captive research permit that is issued to the Monterey Bay Aquarium. They are a collaborating institution with many aspects of our research program, especially the projects involving advancement in tagging technology. We do not request any separate or new approvals to test methodologies on captive otters, since our current collaborative activities are permitted under the existing captive permit at the Monterey Bay Aquarium.

i. Other procedures/activities; list each additional procedure/activity and provide a detailed description of each, including all appropriate mitigation measures (note, we might contact you

with follow-up clarification of methodologies), novel procedures, and any procedures involving active acoustic or hearing studies).

We are requesting a continuation of the collection of salvaged specimens (carcasses and/or parts) from beaches and the clarification that this may occur throughout the range of the Southern sea otter, and beyond, since dead otters sometimes wash up extralimitally and present especially interesting cases when determining the cause of death. Table 1 states that we reserve the right to collect samples from carcasses of sea otters that have stranded anywhere in the state of California. These samples include the entire carcass for necropsy, but specifically: the collection of adipose tissue, external pathology, liver biopsy, premolar tooth, all teeth, skin plugs, vibrissae, baculum, skull and fur from the carcass. The recovery of sea otter carcasses provides an invaluable opportunity for determining the most important causes of death and threats facing the wild sea otter population. We work with our partners at the California Department of Fish & Wildlife to recover and necropsy beach-cast sea otter carcasses throughout the state.

21. For each procedure/activity, provide the information in a-j, below, including the maximum number of animals of each species expected to be taken by the procedure annually, broken down by sex and age class; the number of takes per animal per year; and an estimate of the number of animals of the study species that might be incidentally harassed (i.e.,# of non-target animals of your study species that might be harassed by your activities). Also, include the time-periods and specific locations of the takes. This information may be provided in table format such as:

Note that although we have many takes (over 600) left over on our existing (recently expired permit), for the sake of simplicity we are not requesting that any of those takes be carried over. We just present the number of takes we are requesting for the 5-yr duration of this renewal.

Table 2

a. Species	b. Procedure / Activity	c.Level A or Level B Harassment *or other Take**	d.Age Class (see question 23, below)	e. Sex	f.Max. # Animals Per Year	g.Max. # Takes Per Animal Per Year	h.Max. # non-target conspecifics incidentally harassed	i.Time-period	j. Location
Enhydra lutris nereis	Capture	600	All	Both	120	3	1250	5-year permit duration	Entire Range

Table 3. This table states the total number of captures we are requesting for the duration of this 5-yr permit. It also states that of the total captures, a sub-sample will undergo anesthesia and sampling, and a further subsample with undergo surgery to implant or remove instruments. We are requesting authorization for Level B harassment of up to 1250 (250/year) during capture activities.

	TOTAL TAKES (CAPTURES)	TOTAL FOR ANESTHESIA/TAG/TISSUE SAMPLES	TOTAL FOR SURGERY IMPLANT/EXPLANT	LEVEL B HARASSMENT (FOR 5 YR DURATION OF PERMIT)
TOTAL REQUESTED	600	300	150	1250

22. Will any female-pup/calf/cub pairs be targeted for any of the proposed research activities? If so, describe how you would minimize impacts on pups/calves/cubs and associated females during each of those activities.

Yes, female-pup pairs may be targeted for our research activities. Since most of our research aims to answer questions about reproduction, survival, and population dynamics, avoiding the capture of mothers and pups would severely bias our research and result in inaccurate conclusions.

Immediately after capture, the mother and pup will be transferred to a holding box, like all captured otters. In general, the mother and pup are placed in the same holding box. However, certain instances may dictate that holding the mother and pup in separate boxes would be the most prudent course of action. For example, if the pup is quite small and the mother is not showing clear maternal behavior towards the pup, it might be safer to keep the pup in its own box, to prevent any possibility of incidental injury to the pup. At the other end of the spectrum, sometimes very large pups are as big as the mother. In this case, the mom and pup might be placed into separate holding boxes so that both otters can have sufficient space. Mothers and pups, regardless of age or pup size, are always released together to reduce the chance of separation.

Females with pup may be subjected to all the normal veterinary procedures that any captured sea otter would normally be subjected to. This includes surgery for the implantation of VHF radio transmitters. In addition, sterile oxytocin (20 units/ml) may be injected intramuscularly to facilitate milk letdown in lactating females. Oxytocin, a hormone produced by the hypothalamus stimulates contraction of the smooth muscle of the mammary glands to release milk. We will only attempt to collect milk samples from females with dependent pups, no pregnant females or females without pups will be given oxytocin.

In general, the size of the pup dictates what samples, tags, or procedures are performed on the pup. The pup must weigh at least 20 lbs to qualify for and instrument implantation. Additionally, only pups greater 11 lbs will be flipper tagged. Pups weighing less than 6 lbs will not be PIT-tagged. Pups of all sizes may have morphometric data (e.g. length, weight) and demographic data (e.g. sex) collected.

Given that our estimated time from capture to release is 2 hrs, it's fair to say that the max time that a mother and pup would be separated is for this entire 2hr duration. In practice, the timing is much shorter, since the mother and pup usually share a holding box. If the mother is anesthetized for surgery, the pup will only be separated from the mom during the surgical procedure. This is typically <1 hr.

We take all the necessary precautions to ensure that a separation of mother and pup does not occur. In fact, due to our precautions and the strong mothering instinct of female sea otters, a separation would be considered an extremely rare event. Therefore, reuniting a mother-pup pair is something that is almost never required in our work. As one of our precautions, we observe the behavior of the mother and pup together, in the holding box, to make sure their behavior is still indicative of a bonded pair (e.g. mother holding or grooming pup) before releasing them. We will also employ a "soft release" technique with moms and smaller pups. This method involves submerging the box on its side, about halfway in the water at the side of the boat, then slowly opening the door of the box. The otters will usually calmly swim out of the box.

However, in the extremely unlikely event of a separation, this would probably occur by virtue of the mother immediately leaving the holding box upon release, and leaving the pup behind in the box. This is only a concern with a small pup since larger pups are capable of swimming on their own and catching up to their mother. If a small pup is left behind in the box, the persons conducting the release will immediately remove the pup from the box and place it in the water to float. Releases are always done with the boat placed upwind so that the mother can smell her pup if she initially leaves without it. This will aid her in relocating her pup when she inevitably returns to look for it. In an extreme situation where the mother doesn't immediately return for the pup, the pup is held high in the air so that the sound of the pup's call can travel a greater distance, enticing the mother to return and retrieve her pup. If this still does not work, the pup will be left at the site of release, and the boat will back away. Our shore spotters will monitor the pup through a high-powered spotting scope to see if the mother returns to claim the pup. Should these attempts fail and the mother does not return, the pup will be rescued by the boat crew, and brought back into veterinary team. At the discretion of the lead veterinarian, if it is deemed that the pup has truly been abandoned, the pup may be raised in captivity at the Monterey Bay Aquarium as part of their surrogacy program, and could be released back into the wild once mature. We have never had to resort to this final step in many hundreds of wild sea otter captures.

23. Define each age class listed in your response to question 21(d), above, for each species (i.e., list the range of months or years (or mass for otters) constituting each age class); provide the minimum age (or mass) that animals will be targeted for take activities; and indicate whether females with calves/pups/cubs less than that minimum age will be targeted for take activities?

We listed "all" for age classes targeted in 21(d). This is because of the nature of our research. It is impossible to do a study looking at population-level effects concerning movement patterns, diet, and survival if you only target certain age classes. Furthermore, it is difficult to determine the age class of a sea otter until have you have captured an examined the otter. The most reliable estimator of age comes from a dental examine, which requires a captured and anesthetized sea otter. Still, when we discuss different age classes, we break them down as follows:

Dependent pup
- Very small (<3 weeks old)
- Small (3-10 weeks old)
- Large (>10 weeks old)

Juvenile: 6 months to 1 year old
Sub-adult: 1-3 years old
Adult: 3-10 years old
Aged (Old) Adult: 10+ years old

As mentioned in responses to 10(h), whenever possible, very small/newborn pups are generally avoided when attempting to capture sea otters. However, very small pups are sometimes captured anyway, since they can be difficult to see. Even if they are seen, age can be difficult to determine depending on sightability of the pup, ocean conditions, and the experience level of the observer. If a very small newborn pup is observed, we will usually not attempt to make the capture of the mother-pup pair. But because this cannot always be determined ahead of time, we are requesting permission to capture all age classes of sea otters, including small pups. We just wanted to make it known that when we are conducting sea otter captures we always have the best interest of the sea otters in mind. If a marginal situation presents itself in terms of the presence of a very small pup (as determined by our experienced personnel) we will always act in the best interest of the sea otters. The actions we take could include the avoidance of the mother-pup pair, but this depends on the situation. We don't have any data to support any assertion that capturing tiny pups is more risky than capturing larger pups, but the small size of the pups leads us to act with an abundance of caution. Pups must weigh at least 11lbs to qualify for flipper tagging, and must weigh at least 20lbs to qualify for instrumentation.

24. Describe the precautions that will be taken to minimize the likelihood that harassment of non-target individuals of the study species will occur and the actions that will be taken should harassment occur.

As previously described in the response to question 10(f), any incidental harassment is almost always due to the habit of sea otters resting in groups or rafts. When capturing target otters in a raft, nearby otters may be disturbed. We always try to minimize the disturbance or incidental harassment of non-target otters. The rebreather diver techniques described previously are the best way to minimize incidental harassment, because the divers remain undetected for the entire dive, until the moment of capture. Our captures are most successful when we are completely undetected, so minimizing incidental harassment is inherent to the success of our work. When possible, we avoid targeting an animal when it's in a very large group of otters. The odds of successful capture decrease when the target is resting in a large group. Sometimes this cannot be avoided, however, most capture attempts are on solo animals, animals in pairs, or otherwise small rafts.

25. Explain how you determined that your methods involve the least possible degree of pain and suffering and why there are no feasible alternative methods to obtain the desired data or results.

Because of the broad, comparative nature of our research, captive animals are not appropriate surrogates for behavior or habitat use studies of wild sea otters, nor will they allow assessment of the survival, reproductive success, health and body condition of their wild counterparts. The only way to conduct these types of studies is through the capture and marking of individual wild sea otters. In order to continue to study behavioral, life history, and physiological characteristics of the threatened southern sea otter and to compare populations across geographical regions, wild animals from those populations must be sampled. When possible, data and/or samples will be obtained from beach-cast carcasses rather than live-captured animals.

Our methods have proven efficient and effective for many decades, but more importantly, they have also been refined at every available opportunity. We have learned a lot over the years and we believe that our current techniques represent the best and safest methods in existence, for this type of research.

The techniques described in this permit application have been honed and refined over the past 25+ years in order to reduce the likelihood of adverse health impacts, mortalities, pain, or suffering. Since sea otter capture and tagging is very specific and highly specialized work, there is no industry standard for the "least possible degree of pain and suffering" in this species. As a result, every action we take is aimed at minimizing pain and suffering during the capture and tagging process. The list of co-investigators includes more than 12 licensed veterinarians and vet techs, as well as biologists with a combined 400+ years of experience capturing, tagging and handling wild sea otters. As such, the assemblage of veterinarians and biologist on this permit comprises the most experienced sea otter personnel in the world, and we take pride in our ability to set the standard of safe and responsible handling of sea otters. We also heavily rely on the experience of our 12 veterinarians when it comes to ensuring that the least possible degree of pain and suffering is being employed through our research. Our veterinarians are all experienced in sea otter health assessments and veterinary care, but they come from many different institutions and all have diverse backgrounds in the care of marine mammals, as well as a huge diversity of other species from terrestrial mammals to reptiles, birds, fish and invertebrates. The invaluable experience and knowledge base of this incredible team of veterinarians and sea otter biologists makes them exceeding qualified to determine the standards of care that our study animals receive, and every member of our team always acts with the best interest of the sea otters in mind.

Some examples of the protocol changes that we have made to reduce the likelihood of adverse effects, and minimize pain and suffering include:

- Wrapping of plastic hose around all metal parts of Wilson traps and dip nets that otters could potentially bit so as to prevent tooth damage
- Extensive improvements to capture boxes (increased ventilation, no "bitable inner edges", false bottoms that keep the otters fur separate from water or fouling materials)
- Reducing total animal processing time to under 2 hours
- Better management of otter thermal conditions prior to surgery (including sea-water soaks immediately prior to anesthesia)
- Modification of the anesthetic and surgical procedures to reduce overall invasiveness and improve recovery time
- Switching to temperature-sensitive PIT tags so as to be able to closely monitor body temperature in real-time after drug reversal (but prior to release) to ensure appropriate surgical recovery.

Because of these and other protocol changes, we have continued to improve the outcomes for study animals and reduced the potential for accidental lethal takes to very low levels, while also minimizing any pain and suffering that the otters might incur. We take this very seriously, and have spent untold hours and funds ensuring the well-being of the sea otters we capture.

26. Provide: a) an estimate of the possible number of unintentional deaths or serious injuries that might result from your research activities; b) the number of unintentional and intentional (via euthanasia for humane purposes if an animal is seriously injured) deaths or serious injuries you seek approval for annually; c) the steps you will take to reduce the likelihood of deaths or injuries; and d) if euthanasia might occur, provide the method of euthanasia (e.g., gunshot, drug, etc.) and who would conduct the euthanasia procedure.

Our current permit requires notification of the permit office after one mortality that occurs during capture operations (where there is reasonable cause to suspect that the death was caused by our activities and is thus an accidental lethal take), and cessation of all activities after 2 such mortalities. We would therefore request no more than 2 accidental lethal takes for this permit renewal (with the specification that post-mortem necropsies by a veterinary pathologist indicate that the mortalities in question were indeed caused primarily or entirely by our activities rather than by some unrelated factor). In the unlikely event that a moribund animal needs to be humanely euthanized, this will be determined by the lead veterinarian, and euthanasia will be by drug injection.

28. If a female animal accompanied by calf/pup/cub(s) dies during research activities, specify the disposition of the associated calf/pup/cub(s).

In this highly unlikely scenario, we have a very good solution that is generally not available to other marine mammal researchers. Since we work collaboratively with the Monterey Bay Aquarium, we have the option of admitting the orphaned pup into their surrogacy program. This program allows the pup to be fostered by a captive sea otter mother until it has reached maturity, at which time the pup can be re-released to the wild. The Monterey Bay Aquarium surrogacy program has a long and successful track record for reintroducing stranded or orphaned pups back into the wild. This would be our first and most desired outcome in this unfortunate scenario. If the Monterey Bay Aquarium cannot accommodate the pup (i.e. if there is no room) we can inquire with other captive facilities. If placement for the pup is impossible, the only alternative would be euthanasia.

29. If biological samples are to be collected or received domestically, provide responses to a through j, below, for each individual animal per species. This information, or part of the information, may be provided in table format such as the table below. (Note: if your only proposed activity is to transfer dead marine mammal specimens for purposes of public display or scientific research, complete application Form 3-200-87).

Table 4. The following samples will be taken from both sexes of southern sea otters of all age classes, from live and dead specimens with the following exceptions: no samples will be taken from live pups less than 11 pounds in weight and no pre-molar teeth will be extracted from live pups or juvenile sea otters. Up to 120 southern sea otters will be sampled per year and individuals will be sampled no more than 3 times per year. All samples listed have been approved on our previous permit.

a. Species	b. ID #	c. Sex	d. Source (Wild or Captive/Live or Dead)	e. Birth Date or age class	f. Type of Samples (blood, tissue, DNA)	g. Number of animals sampled annually	h. Number of times each animal will be sampled annually	i. Packaging and Preservation of samples	j. Use/Disposition of Samples
Enhydra lutris nereis	N/A	Both	Wild/Live	All >11 llbs	Blood	60	3	Stored at Monterey Bay Aquarium or CA DFW	Hematology, clinical chemistry, infectious disease monitoring, biomarkers, contaminants
Enhydra lutris nereis	N/A	Both	Wild/Live	All >11 llbs	External Swabs (integument, oral cavity, rectum, genital orifice)	60	3	Stored at Monterey Bay Aquarium or CA DFW	Infectious disease (bacterial, fungal, parasitic, viral), contaminants, gene ics
Enhydra lutris nereis	N/A	Both	Wild/Live	All >11 llbs	Saliva	60	3	Stored at Monterey Bay Aquarium or CA DFW	Hormonal assays
Enhydra lutris nereis	N/A	Both	Wild/Live	All >11 llbs	Feces (from animal)	60	3	Stored at Monterey Bay Aquarium or CA DFW	Diet assessment, infectious disease (bacterial, fungal, parasitic, viral), contaminants, biotoxin, hormonal assay
Enhydra lutris nereis	N/A	N/A	Environment	N/A	Feces (from environment)	N/A; No limit	N/A; no limit	Stored at Monterey Bay Aquarium or CA DFW	Diet assessment, infectious disease (bacterial, fungal, parasitic, viral), contaminants, biotoxin, hormonal assay
Enhydra lutris nereis	N/A	Females	Wild/Live	All adult	Milk	60	3	Stored at Monterey Bay Aquarium or CA DFW	Nutritional content, fatty acid analysis, contaminants
Enhydra lutris nereis	N/A	Both	Wild/Live	All >11 llbs	Urine	60	3	Stored at Monterey Bay Aquarium or CA DFW	infectious disease, toxins, urinalysis, contaminants
Enhydra lutris nereis	N/A	Both	Wild/Live	All >11 llbs	Adipose Tissue	60	3	Stored at Monterey Bay Aquarium or CA DFW	Fatty acids, contaminants
Enhydra lutris nereis	N/A	Both	Wild/Dead	All	Adipose Tissue	N/A; no limit	N/A; no limit	Stored at Monterey Bay Aquarium or CA DFW	Fatty acids, contaminants
Enhydra lutris nereis	N/A	Both	Wild/Live	All >11 llbs	External pathology (integument, oral cavity, genital orifice)	60	3	Stored at Monterey Bay Aquarium or CA DFW	Histopathology, genetics, etiopathogenetic investigation
Enhydra lutris nereis	N/A	Both	Wild/Dead	All	External pathology (integument, oral cavity, genital orifice)	N/A; no limit	N/A; no limit	Stored at Monterey Bay Aquarium or CA DFW	Histopathology, genetics, etiopathogenetic investigation

Enhydra lutris nereis	N/A	Both	Wild/Live	All adult	Liver biopsies	60	3	Stored at Monterey Bay Aquarium or CA DFW	Histopathology, toxicology, contaminants, genetics, chemical analysis (ie, Vit A analysis)
Enhydra lutris nereis	N/A	Both	Wild/Dead	All	Liver biopsies	N/A; no limit	N/A; no limit	Stored at Monterey Bay Aquarium or CA DFW	Histopathology, toxicology, contaminants, genetics, chemical analysis (ie, Vit A analysis)
Enhydra lutris nereis	N/A	Both	Wild/Live	All adult	Premolar tooth	60	1	Stored at Monterey Bay Aquarium or CA DFW	Cementum aging
Enhydra lutris nereis	N/A	Both	Wild/Dead	All	Premolar tooth	N/A; no limit	N/A; no limit	Stored at Monterey Bay Aquarium or CA DFW	Cementum aging
Enhydra lutris nereis	N/A	Both	Wild/Live	All >11 lbs	Skin plugs	60	3	Stored at Monterey Bay Aquarium or CA DFW	Genetics
Enhydra lutris nereis	N/A	Both	Wild/Dead	All	Skin plugs	N/A; no limit	N/A; no limit	Stored at Monterey Bay Aquarium or CA DFW	Genetics
Enhydra lutris nereis	N/A	Both	Wild/Live	All >11 lbs	Vibrissae	60	3	Stored at Monterey Bay Aquarium or CA DFW	Stable isotope analysis
Enhydra lutris nereis	N/A	Both	Wild/Dead	All	Vibrissae	N/A; no limit	N/A; no limit	Stored at Monterey Bay Aquarium or CA DFW	Stable isotope analysis
Enhydra lutris nereis	N/A	Males	Wild/Dead	All	Baculum	N/A; no limit	1	Stored at Monterey Bay Aquarium or CA DFW	Morphometrics, stable/radio isotopes
Enhydra lutris nereis	N/A	Both	Wild/Dead	All	Tooth	N/A; no limit	N/A; no limit	Stored at Monterey Bay Aquarium or CA DFW	Cementum aging
Enhydra lutris nereis	N/A	Both	Wild/Dead	All	Skull	N/A; no limit	1	Stored at Monterey Bay Aquarium or CA DFW	Morphometrics, stable/radio isotopes
Enhydra lutris nereis	N/A	Both	Wild/Live	All >11 lbs	Fur	60	3	Stored at Monterey Bay Aquarium or CA DFW	Hormonal assays, toxins, contaminants
Enhydra lutris nereis	N/A	Both	Wild/Dead	All	Fur	N/A; no limit	N/A; no limit	Stored at Monterey Bay Aquarium or CA DFW	Hormonal assays, toxins, contaminants

In addition: All animals captured or sampled under this permit will be wild born. Any specimens collected will be transferred to, and archived at, the Marine Wildlife Veterinary Care and Research Center, Department of Fish and Wildlife, located at Long Marine Lab in Santa Cruz. They may be retrieved from this location for further analysis. Unused portions of samples will be archived at either the Marine Wildlife Veterinary Care and Research Center (California Department of Fish and Wildlife, located at Long Marine Lab in Santa Cruz) or the Monterey Bay Aquarium, where appropriate -80 freezers (with redundant power back-up) exist. A database is maintained that provides the current disposition of each sample at any point in time.

k. Provide a detailed description of the source of the specimens, including the circumstances under which the animals were/will be taken. For example, this might include the following sources:

The source of all samples will be from live captured wild otters as previously described, or from stranded/dead/beach-cast carcasses. Because of the broad, comparative nature of our research, and the need to obtain representative data from throughout the range (and over all seasons and across years) on all population parameters, sampling may occur at any location within the current range of southern sea otters (Fig 2), or extralimitally if an otter strands outside of the current range, and at any time of year within the time period covered by the permit.

i. Animals stranded alive or dead;
Samples may be obtained from dead, beach-cast sea otter carcasses. These are noted in Table 1 and Table 4.

ii. Animals killed during legal subsistence harvests;
No, subsistence harvest of sea otters does not exist in California

iii. Animals killed incidental to legal commercial fishing operations;
Yes. Unlikely, but an otter carcass that is killed as a result of commercial fishing activities could be sampled. Sometimes the cause of death is not immediately apparent until the samples are taken and the necropsy conducted.

iv. Samples from other authorized researchers or collections;
We will not be obtaining samples from other researchers or collections. All samples will be obtained by us, via this permit.

v. Soft or hard parts that are sloughed, excreted, or discharged naturally;
No, N/A

vi. Samples that will be/were intrusively collected from captive-held animals;
No, N/A. Our samples are from wild animals.

vii. Samples that will /were collected from wild animals.
Yes. As previously described, our samples will be from live-captured wild otter or dead beach-cast carcasses of wild otters.

l. If collecting samples from live animals, describe how the samples were/will be collected, including animal handling and sample collection protocols.
All the samples already listed will be collected by one of the veterinarians or veterinary staff under the supervision of a veterinarian listed on this permit. All samples are collected while the otter is sedated. Some non-invasive measurements may be collected without sedation (e.g. weight) but the animal is sedated for all actual sampling. Blood is collected intravenously from the jugular vein. External swabs are collected manually, by swabbing the areas or orifice specified. Saliva is collected manually from the mouth. Fecal samples are collected manually from the rectum. Milk is manually expressed from the mammillary glands of lactating females. Urine is collected via cystocentesis (syringe and needle) or occasionally “free catch.” Adipose tissue is manually collected via surgical excision during the surgical procedure. External pathology is collected manually usually via swab. Liver biopsies are taken manually using clam-shell biopsy forceps during the surgical procedure. The premolar tooth is removed manually using a dental elevator. Skin plugs are collected manually from the webbing of the hind flipper using a sterile leather

punch. This procedure is necessary to apply flipper tags, so the skin plugs are saved for genetic analyses, providing multiple data types/uses for a single procedure. Vibrissae are manually plucked from the muzzle. Fur is manually plucked from the exterior pelt.

m. For samples received domestically from U.S. permitted researchers, include the researcher's name, affiliation, and permit number under which samples will be/were collected. (Note: if samples are to be imported, you must answer question 12, above).
N/A

30. Provide a list of all personnel that will be involved in the project, identifying each as either a principal investigator or co-investigator, their project duties/responsibilities, and a brief description or CV that demonstrates their experience and expertise to perform their designated duties, including knowledge of the marine mammal species that is/are the subject of this application.

Applicant (Project Lead): Joseph Tomoleoni, Biologist, Sea Otter Project Leader, U. S. Geological Survey, Western Ecological Research Center. Joe's primary interests are in areas of population, behavioral and community ecology. He has worked with sea otters in Alaska, California, and Washington for over 10 years and has extensive experience with capture, tagging, and handling of wild otters. Joe is a rebreather diver and has participated in more than 40 sea otter capture events, and more than 150 sea otter capture dives under previous versions of this permit. Joe has prior experience as the Project Lead for sea otter captures, including as the designated interim project lead for otter re-captures in Santa Barbara, California (2014), in the absence of the previous permit holder, Tim Tinker, and as the lead for all sea otter captures that occurred in 2018.

Existing Permittees (Co-Investigators): Brian Hatfield, Michael Kenner, Jack Ames, Michelle Staedler, Daniel Costa, Benjamin Weitzman, Colleen Young, Michael Murray (DVM), Terrie Williams, James Estes, Mike Harris, James Bodkin, Daniel Monson, George Esslinger, Seth Newsome, Brent Hughes, Zachary Randell, Christine Fiorello (DVM), Nancy Anderson (DVM), Lesanna Lahner (DVM), Raymond Wack (DVM), Heather Harris (DVM), Melissa Miller (DVM), and Christine Kreuder-Johnson (DVM).

AMMENDMENT REQUEST: We would like to add the following personnel to our permit. Their CVs are included in this application packet.

<u>M. Tim Tinker, PhD:</u> Dr. Tinker was the previous P.I. and permit holder for this permit. He was also the previous Sea Otter Project Leader for USGS before leaving the service in 2017. We would like Tim to be listed on this permit as a co-investigator, since he is still involved with our research program, just no longer the leader. Tim has over 25 years of experience working with sea otters in California, Alaska, Russia, Washington, and British Columbia, and has participated in countless sea otter capture events, leading most of them.

<u>Dave Casper, DVM</u>: Dr. Casper serves as the Director of Veterinary Services, as well as the attending veterinarian for UCSC's Long Marine Lab and Moss Landing Marine Labs, while also performing services as a contract veterinarian for the Monterey Bay Aquarium. He has more than 30 years of experience working with a variety of marine mammals and other marine megafauna in the field. Dr. Casper has extensive veterinary experience with Southern sea otters, having worked extensively with sea otters for the past 18 years.

<u>Nicole Thometz, PhD</u>.: Dr. Thometz is an assistant professor at the University of San Francisco, and is a broadly trained physiological ecologist who specializes in marine mammal physiology, ecology, and behavior. Nicole has approximately 10 years of

experience working with captive and wild sea otters in a research capacity, and has assisted in numerous sea otter capture events since 2008. A new USGS research project collaborating with the Thometz Lab at USF will aim to investigate the foraging energetics and diet composition of southern sea otters at the northern extent of their range.

Shawn Johnson, DVM: Dr. Johnson is Director of Veterinary Science at The Marine Mammal Center and oversees all of the Rescue, Animal Care, Diagnostic Services, and Research activities. Dr. Johnson has more the 20 years of marine mammal veterinary medicine experience and has cared for sea otters in rehabilitations at the Alaska SeaLife Center and The Marine Mammal Center and participated in two sea otter captures trips performing anesthesia, sampling, and implant surgeries under the guidance of Dr. Mike Murray.

Cara Field, DVM: Dr. Cara Field is the Staff Veterinarian at The Marine Mammal Center (TMMC) in Sausalito California, since October, 2014. Her primary roles include managing the care and rehabilitation of our marine mammal patients including sea otters, as well as carrying out research projects and teaching our veterinary intern and visiting veterinary residents, international vets and students among others. Sea otter specific experience includes primary medical care of 2 captive sea otters at Audubon Nature Institute for 2.5 years, medical care of 5 captive sea otters at Georgia Aquarium for 2.5 years, primary responsibility for the rehabilitation of sea otters at TMMC, collaboration with the Monterey Bay Aquarium sea otter rehabilitation program, participation in sea otter transmitter implant surgeries, and collaborator with the US Fish and Wildlife and OWCN response groups.

Claire Simeone, DVM: Dr. Claire Simeone is a veterinarian with The Marine Mammal Center and has seven years' experience working with marine mammals, including sea otters. She has provided medical care for sea otters both in a rehabilitation and captive setting, and has sedated roughly a dozen southern sea otters. She has performed both implant and explant surgeries under the observation of Dr. Mike Murray.

Marissa Young: Marissa started at the Monterey Bay aquarium in August 2004 as an Animal Care volunteer in the Sea Otter Program. She volunteered for a 5 ½ hour shift once weekly. She began a full-time paid staff position at the aquarium in August 2005, again covering animal care with the Sea Otter Program and working with Dr. Mike Murray in the capacity of a Registered Veterinary Technician. That equates to almost 15 years of experience with capture, handling, restraint, medical care and anesthesia monitoring for southern sea otters.

Julie Yee, PhD.: Dr. Yee is the new Principle Investigator for the USGS Santa Cruz Field Station's sea otter research program. Dr. Yee is trained as a statistician, but is currently assimilating into to her new role as program PI. Although she has little prior experience working with sea otters, her involvement in this permit is necessary as the new lead of the program. Dr. Yee will have the opportunity to be involved with sea otter captures and learn techniques from the many other experienced researchers listed here, but her opportunities to work hands-on with sea otters will be limited.

31. Describe how you will collaborate or coordinate with other researchers in your study area. Who are they? Explain how this will occur and how it will minimize negative impacts on the species. For example, will it involve sharing resources, samples or data; timing surveys to minimize disturbance, etc.?

Our research program has a long history of collaborating with other researchers in our immediate area, as well as those around the country. Any time we conduct sea otter captures we work directly with the Monterey Bay Aquarium and the California Department of Fish & Wildlife. Descriptions of the roles of our collaborators follow below:

USGS Western Ecological Research Center: The lead agency conducting sea otter research in California. Secures permits and funding, develops proposals for novel research, spearheads the effort to better understand sea otters and their role as keystone predators in nearshore ecosystems. During otter captures, USGS Project Lead serves as the overall leader for capture operations, but makes decisions with senior staff from collaborating agencies and institutions. USGS provides vessel support, divers, boat operators, shore spotters, and general assistance during capture. USGS also provides most of the equipment, including holding boxes other specialized items. The Survey is ultimately responsible for the collection of all data on the project. USGS performs analyses and writes up results for publication in reports and peer-reviewed journals. The findings of these USGS-led studies are useful to the USFWS and a host of other agencies in making management decisions regarding the status and future of Southern sea otters.

Monterey Bay Aquarium: Provides primary veterinary support and expertise, led by veterinarian Dr. Michael Murray. MBA provides animal health care staff including vet techs, and provides access to their state-of-the-art Animal Health Lab, which allows the otters to be processed and cared for in an exceptional facility that would rival any high end hospital in the country. The veterinary team also contributes drugs and medication involved in the work. Additionally, MBA provides leadership and coordination of all shore activities. MBA also provides skilled shore spotters during capture operations, as well as general hands to help transport animals and equipment. MBA occasionally provides some vessel support. The Monterey Bay Aquarium is very involved in the post-release monitoring of study animals, and assists USGS with the primary data collection duties for the duration of each study.

California Department of Fish & Wildlife: Provides staff support in the form of boat drivers, boats, and equipment for sea otter captures. May provide some veterinary assistance. Provides blood processors and the equipment necessary for this task (centrifuges, freezers, etc.). CDFW also provides a Mobile Veterinary Lab for more remote capture operations. Because CDFW employs experience pathologists, they perform the necropsies on most dead sea otters that wash up in California, including all study animals.

In addition to the core collaborators above, we also receive logistical, staff, equipment, and analytical support from various other agencies and institutions, including the United States Fish & Wildlife Service, the USGS Alaska Science Center, the University of California Santa Cruz, the University of California Davis, the University of New Mexico, the Elkhorn Slough National Estuarine Research Reserve, the Santa Barbara Zoo, the Marine Mammal Center, and many others.

32. If you intend to conduct research on animals in a captive-holding facility such as a zoo or aquarium, provide documentation showing that the facility(ies) has authorized you to conduct your proposed activities.

N/A

33. Animal Welfare Act (AWA) Compliance (for research on live animals only): AWA requirements apply to all research facilities, which include institutions, organizations, or people that use or intend to use LIVE animals in research, tests, or experiments; AND, that receive funds under a grant, award, loan, or contract from a department, agency, or instrumentality of the U.S. for the purpose of carrying out research, tests, or experiments, or acquires or transports the animals in commerce. Provide the following documentation:

N/A. We will not be housing any animals for research purposes thus APHIS/AWA registration is not required. We capture and sample sea otters in the wild and release them immediately post-processing.

a. Registration under the AWA as a research facility:

i. Attach a copy of your APHIS certificate of registration as a research facility, or for Federal facilities, a letter from your Institutional Officer that you are compliant with applicable requirements for scientific research under the AWA; OR

ii. If your facility does/will not conduct activities requiring registration under the AWA, attach a letter from APHIS confirming that registration is not required.

N/A. We will not be housing any animals for research purposes thus APHIS/AWA registration is not required. We capture and sample sea otters in the wild and release them immediately post-processing.

b. Institutional Animal Care and Use Committee (IACUC) documentation: If your facility is registered as a research facility under the AWA or is a Federal research facility (see a.i), attach the applicable IACUC documentation from the list in i-iii, below. Please note that all activities that involve an invasive procedure, harm, or materially alter the behavior of an animal under study, even if the activities are carried out in the field, are subject to IACUC review and approval. See (AWA regulations and standards for definition/explanation of covered research activities.):

i. Attach a copy of your final protocols with the IACUC signed approval; OR

ii. Attach a copy of your proposed protocols to be reviewed by your IACUC along with an explanation as to how and when the protocols will be reviewed (Note: A copy of your final signed protocols and certification will be required prior to permit issuance.); OR

iii. Attach the IACUC determination that your research activities are not subject to IACUC review and approval.

Our ACUC approval of our capture and handling SOPs has been granted. Please see attached ACUC approved SOP for sea otter research.

c. If your facility is not registered as a research facility under the AWA, please provide an explanation of how your take activities are reviewed and monitored to assure that the proposed takes are humane (i.e., using the method that involves the least possible degree of pain and suffering).

N/A

Innovation Fund 2018 Proposal

Next Generation Wildlife Tracking: A New Paradigm for Environmental Monitoring and Data Retrieval through Hybrid Heterogeneous Networks of Tagged Animals

The problem and the opportunity:

Advanced animal tracking devices that couple cutting-edge technologies with our increasing need for ecological data will be critical tools for managing and conserving species under future land use and climate conditions. In addition to optimizing the size of telemetry units for use on small or sensitive species, new paradigms for collecting, storing and transmitting data on animals and their environments are needed to further advance the next generation of wildlife tracking devices. We propose a follow-on effort to our previous Next Generation Wildlife Tracking development work. Phase 3 of our USGS-NASA collaborative project will mature the two tag architectures developed under Phase 1 (satellite communications tag) and Phase 2 (networked tags), and will explore new hybrid architectures enabled by using a mixture of the two tag types (e.g. heterogeneous networks).

Our successful Phase 1 and 2 efforts have resulted in several advances that address issues associated with modern day telemetry units. During Phase 1, we developed a novel tag to satisfy the challenging goals of providing a light-weight, energy-efficient, and low-cost device that could transmit geolocation and environmental sensor data via commercial satellite (Fig. 1). Additionally, research conducted in Phase 1 identified the need for a smaller, lighter, lower-cost tag that could collect and exchange data with other tags. Such information sharing among animals is a novel approach to maximizing data collection and delivery that has the added benefit of detecting patterns of association among individuals and subpopulations. In a peer-to-peer tracking network, animals can exchange stored location, activity, body condition, and environmental data when in close proximity, thereby improving energy-efficient data recovery (one individual can upload data from many; Fig. 2) and shifting the wildlife telemetry framework from geospatial tracking of a single animal, to one that can also acquire data about population connectivity.

In Phase 2, we developed peer-to-peer tracking capabilities (Fig. 3) and refined the early prototype satellite-communications tag created in Phase 1 to incorporate a unique antenna capable of both receiving GPS signals and transmitting to the Globalstar satellite constellation. Our Phase 2 work has advanced both devices, as well as a base station design for use with the networked tags, to the point of readiness for field testing. Research in Phase 2 also indicated the potential for "hybrid architectures" comprised of both multiple, interconnected networked tags, and one or more satellite tags. Such hybrid architectures offer the potential to leverage species associations with surrounding animal populations, and provide a mechanism for the data acquired by networked tags on small species to be collected by the satellite tags sited on larger species and ultimately relayed to scientists.

The overarching goal of our collaborative USGS-NASA Next Generation Wildlife Tracking project is to develop low-cost, modular hardware and custom software that will allow scientists to tailor tag technology for broad species applicability and large-scale deployments. To achieve this goal we have identified three parallel tasks for Phase 3 of our project (see timeline Fig. 4). **In Task 1**, field testing of the first generation of satellite tags, which was started in Phase 2, will be concluded and the results analyzed and incorporated into design revisions and improvements. The improved (Gen 2) satellite tags will be designed and prototypes fabricated. **Task 2** will advance the design of the networked tags. A set of base stations will be fabricated to enable field testing of the 1st-generation networked tags, and a set of tags for testing will be produced. These elements will be field-tested to assess function, radio range, and battery life. The results will be analyzed and used to evolve the tag design and prototype a Gen 2 peer-to-peer tag. For both the satellite and peer-to-peer

tags, software and hardware design and performance will be documented and published upon the completion to Gen 2 working prototypes.

Development of the hybrid architecture described above will form **Task 3**. Satellite and networked tags will be used to implement a hybrid system, which will then be tested to evaluate capabilities and suitability for the anticipated wildlife monitoring use. In particular, the achievable data throughput from the complete system will be assessed, for architecture variations of number of networked tags vs. number of satellite tags and/or base stations. The results of the **Task 3** activities will be documented in a published report. Our approach to all tasks will be open-hardware, open-software with the goal of producing low-cost reference designs that can be adopted, modified, and improved by commercial providers, universities, and other government labs. We will continue to engage with stakeholders from USGS and other agencies, including a developing NASA-BOEM project investigating employment of small satellites for telemetry data transmission.

Overall Goal or MVP (minimum viable product):

The Minimum Viable Product resulting from our collaboration will be a low-cost, miniaturized, wildlife GPS-satellite marking prototype with integrated environmental sensors optimized for size, battery life (or solar cell recharge), and peer-to-peer data transmission. To date, our team has advanced this goal by producing a miniaturized solar GPS-enabled Globalstar satellite transmitter with accelerometer capability (Fig. 2) that is 20% lighter and produced for 25% of the cost of existing commercial tags, as well as a novel peer-to-peer, solar-powered network tag and associated base station hardware. Our Phase 3 work will integrate components developed in Phases 1 and 2 to create a hybridized architecture of networked peer-to-peer and satellite tags.

Objectives and Activities:

Objectives	Activities
Reduce battery size and improve performance	Develop optimized battery using a combination of state-of- the-art technologies including commercially available batteries, NASA-Ames developed 3D-printed battery technology, and/or GaAs thin-film flexible photovoltaic cells for use in recharging batteries to extend life. **(ACHIEVED)**
Integrate environmental sensors	Incorporate between 1 and 3 exchangeable environmental sensors that are integrated into GSM or satellite data transmission systems. **(ACHIEVED – ACCELEROMETER INTEGRATED)**
Develop peer-to-peer networking capability	Build on existing hardware and communication protocols to allow wireless communication (handshake/data sharing) among tagged individuals when in close proximity, thus creating a peer-to-peer tracking network **(ACHIEVED)**.
Integrate system	Integrate Phase 1 and 2 to create a hybridized architecture that allows for networked communication among animals as well as data transmission via satellite
Test and modify designs	Throughout each task we will employ a spiral development approach in which prototype is developed and tested on one or more wildlife species, design is modified and the refined prototype is tested again.

How critical is Innovation Funding for the success of this venture?

Biotelemetry is critical for understanding both threats and conservation opportunities for the Nation's wildlife resources. Emerging technologies offer great promise for innovating wildlife tracking technology and significantly increasing the amount of information we can gain from traditionally hard-to-track species. While commercial telemetry companies have decreased device size and increased location accuracy, progress towards more effective tracking devices has been slow due to limited private-sector research and development. New information from cutting-edge telemetry devices has great applicability for USGS Ecosystems, Climate and Land Use Change, and Core Science Systems; however, development of the

necessary technology is somewhat outside the missions of these programs. Innovation funding, therefore, is an essential catalyst for bringing NASA's state-of-the-art technological research together with USGS ecological science. Our proposed project leverages USGS and NASA capabilities and takes advantage of rapidly-emerging innovations from the tech industry to develop a new device that will advance ecological knowledge. Our successful Phase 1 and 2 products demonstrate the effectiveness of the partnership between USGS and NASA and has resulted in significant advances towards developing our full MVP. Phase 3 development and testing would use additional Innovation Center funding to provide the necessary personnel and raw materials. Adapting consumer technology for wildlife tracking purposes will require manipulation of existing hardware and software to boost signal ranges and enable expanded use in the field. We will allocate requested funds toward new engineering and prototype testing to accomplish our objectives. Success from this project would dramatically improve our understanding of ecological community interactions, thus advancing our ability to conserve the Nation's resources.

Partner goals, contributions and expected technology transfer:

As federal science research agencies, both USGS and NASA have considerable interest in developing novel tools that can be used across the Nation to advance scientific understanding. Our USGS-NASA partnership takes advantage of NASA engineering and emerging technologies and to make advances in the size, utility and cost of wildlife tracking devices. We demonstrated the success of this partnership through our Phase 1 and 2 products, which include development of a working proof-of-concept satellite-GPS tag containing a novel antenna architecture, as well as prototype solar, peer-to-peer network tag. In workshops to demonstrate our Phase 1 and 2 prototypes, USGS researchers studying a wide range of species expressed enthusiasm for using these tools to study topics ranging from open ocean tracking to disease transmission. We propose to build upon previous success to conduct Phase 3, in which NASA will integrate Phase 1 and 2 tags into heterogeneous hybrid networks. This hybrid of close-range wireless transmission among animals and long-range satellite data transmission would be the first of its kind and would open the door to novel applications in wildlife tracking and conservation. We are working on new opportunities to partner with BOEM (J. Levenson) and NASA (A. Martinez) researchers developing a small satellite system for next generation data transmission. Our tags will be designed to integrate with this developing system to promote a complete next generation tracking system. We will continue to use an open hardware, open software approach to produce a broadly transferrable design that can be adopted, modified, and improved to foster additional innovations by private sector manufacturers, universities, and other government labs. The NASA-Ames Research Center (Frost, Kemp) will provide laboratory and "space shop" facilities, hardware and software engineering expertise. USGS will provide expertise on the ecology and marking of several avian and marine mammal taxa and will assist with overall design and testing of transmitter prototypes. This proposal supports multiple goals of the USGS Ecosystems Mission Strategy including: (iv) Developing tools and technologies to inform decision making about ecosystems, and (v) Applying science to enhance strategies for management, conservation, and restoration of ecosystems.

Personnel:

USGS PIs: Susan E. W. De La Cruz, San Francisco Bay Estuary Field Station, 505 Azuar Drive, Vallejo, CA 94592 sdelacruz@usgs.gov, (707) 562-2004; **Center name and location**: Western Ecological Research Center, Sacramento, California ; **Center Director**: A. Keith Miles, keith_miles@usgs.gov; **Center AO**: Tina Palmer, tpalmer@usgs.gov; **USGS collaborators**: Isa Woo, iwoo@usgs.gov; Mike Casazza, mike_casazza@usgs.gov; Cory Overton, coverton@usgs.gov; Josh Adams, josh_adams@usgs.gov; Joseph Tomoleoni, jtomoleoni@usgs.gov; Zachary Randell, randellz@oregonstate.edu **Technology Partners**: Chad R. Frost, Deputy Director, Engineering, NASA Ames Research Center, Moffett Field, CA 94035, chad@nasa.gov, (650) 604-1798; Dayne Kemp, Engineering and Integration, dayne.h.kemp@nasa.gov.

USSG Mission Area alignments:

Our proposal results would contribute towards the goals of the one or two following Mission Areas (check):

☒ Climate and Land Use Change ☒ Core Science Systems ☒ Ecosystems

☐ Energy and Minerals, and Environmental Health ☐ Natural Hazards ☐ Water

May we share your proposal with the Associate Directors for the Mission Areas you checked above?

☐ No ☒ Yes

Budget Summary

Category	Description	In-Kind Contributions	Request
Personnel: USGS WERC	2 PP support for USGS technician, field testing	5 PP WERC PIs wildlife and tracking expertise, field testing, meetings, documentation and outreach	$ 3,374
Personnel: NASA	6 PP Electrical Engineer; 3 PP Software Engineer; 3PP Mechanical Engineer	2 PP support for NASA PI engineering expertise	$ 93,626

Equipment and Supplies	Fabrication, COTs components	"Space shop" testing facilities	$ 10,000
Contracts	Antenna design		$ 20,000
Sub-total			$133, 626 (NASA) $ 3,374 (USGS)
Total	USGS Cost Center rate 25.795% ($870)	NASA funds through IA agreement, ($23,000)	$ 150,000

Commented [A1]: This needs to be adjusted based on actual NASA OH rate

FIGURES:

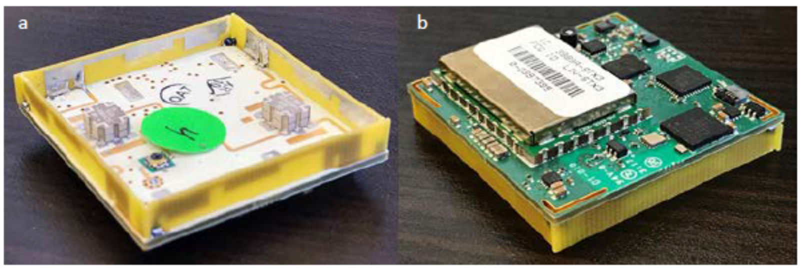


Figure 1. Prototype design for GPS-satellite tag showing (a) novel integrated antenna and (b) build-out of circuitry components. The build out is 20% lighter and 25% the cost of similar commercially available devices.

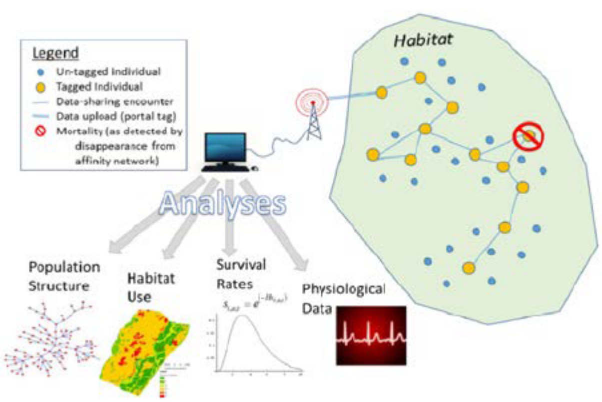


Figure 2. Conceptual model demonstrating capabilities of a peer-to-peer wildlife tracking network. Data are shared among individuals and uploaded from animals marked with portal tags. Analyses of location, sensor and interaction data advances our understanding of population structure, habitat use, survival, physiology and several other critical parameters.

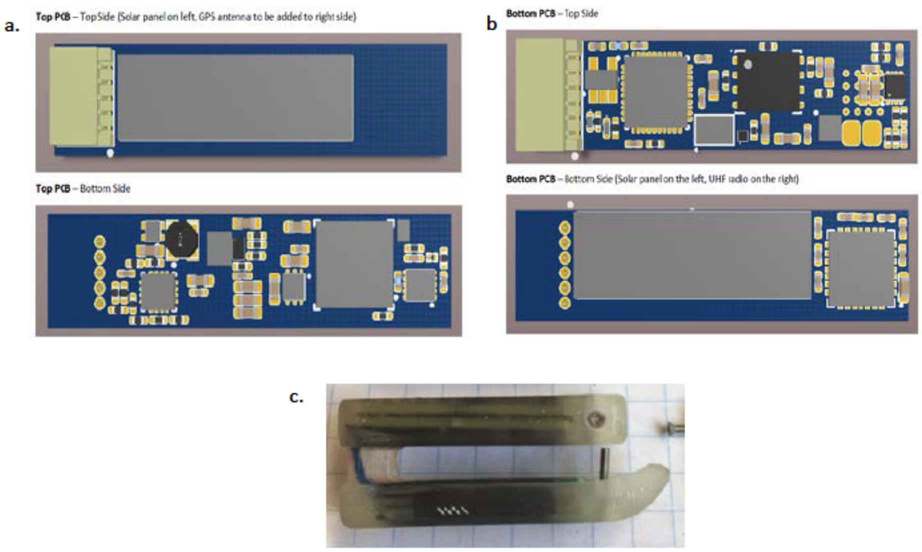


Figure 3. (a) Top and (b) bottom conceptual design of Phase 2 prototype solar, peer-to-peer network tag designed for a (c) flipper or ear tag form factor.

Figure 4. Phase 3 projected timeline.

DEPARTMENT OF THE NAVY
THE ASSISTANT SECRETARY OF THE NAVY
(ENERGY, INSTALLATIONS AND ENVIRONMENT)
1000 NAVY PENTAGON
WASHINGTON DC 20350-1000

December 12, 2016

MEMORANDUM FOR CHIEF OF NAVAL OPERATIONS

SUBJECT: Southern Sea Otter Military Readiness Area Monitoring Plan

Reference: (a) National Defense Authorization Act for Fiscal Year 2016
(b) Endangered Species Act of 1973 (16 U.S.C. 1531 et seq.)
(c) Marine Mammal Protection Act of 1972 (16 U.S.C. 1361 et seq.)
(d) ASN (EI&E) memo to CNO of 13 Apr 2016
(e) USFWS ltr 08EVEN00-2017-B-0020 of 23 Nov 2017

Enclosure: (1) Monitoring and Research Plan for Southern Sea Otter Military Readiness Areas

The proposed Monitoring and Research Plan for Southern Sea Otter Military Readiness Areas, outlined in enclosure (1) is approved.

Background. Section 312 of reference (a), directed the Secretary of the Navy to establish Southern Sea Otter Military Readiness Areas (Sea Otter Areas). Within these designated Sea Otter Military Readiness Areas, Sections 4 and 9 of reference (b) and Sections 101 and 102 of reference (c) shall not apply to incidental takings of any southern sea otters in the course of conducting a military readiness activity.

Reference (d), assigned management, operation and reporting for Southern Sea Otter Military Readiness Areas to the United States Navy and fulfills the requirement to develop monitoring and research parameters and methods in consultation with the United States Fish and Wildlife Service (USFWS).

If you have any questions, my point of contact for this matter is Mr. John Pierson at 703-693-1785, john.c.pierson@navy.mil.

Dennis V. McGinn

cc:
Assistant Secretaries of the Navy
General Counsel of the Navy
DON Assistant for Administration

Monitoring and Research Plan for Southern Sea Otter Military Readiness Areas

U.S. Navy and U.S. Fish and Wildlife Service
in coordination with
U.S. Geological Survey

I. INTRODUCTION

The National Defense Authorization Act for Fiscal Year 2016 (NDAA) includes provisions directing the Secretary of the Navy to establish Southern Sea Otter Military Readiness Areas (Areas) at San Nicolas Island and San Clemente Island (Figure 1). Military readiness activities[1] conducted within these Areas are subject to certain exemptions under the Endangered Species Act of 1973, as amended (ESA) and Marine Mammal Protection Act of 1972 (MMPA). Specifically, with respect to the ESA, Sections 4 and 9 do not apply to the incidental taking of any southern sea otter in the Areas in the course of conducting a military readiness activity, and any sea otter within the Areas is to be treated for the purposes of section 7 as a member of a species that is proposed to be listed as endangered or threatened under the ESA. With respect to the MMPA, Sections 101 and 102 do not apply with respect to the incidental taking of any sea otter in the Areas in the course of conducting a military readiness activity.

The NDAA also specifies monitoring requirements for these Areas:

(1) IN GENERAL.—The Secretary of the Navy shall conduct monitoring and research within the Southern Sea Otter Military Readiness Areas to determine the effects of military readiness activities on the growth or decline of the southern sea otter population and on the nearshore ecosystem. Monitoring and research parameters and methods shall be determined in consultation with the U.S. Fish and Wildlife Service (USFWS).

(2) REPORTS.—Not later than 24 months after the date of the enactment of this section and every three years thereafter, the Secretary of the Navy shall report to Congress and the public on monitoring undertaken pursuant to paragraph (1).

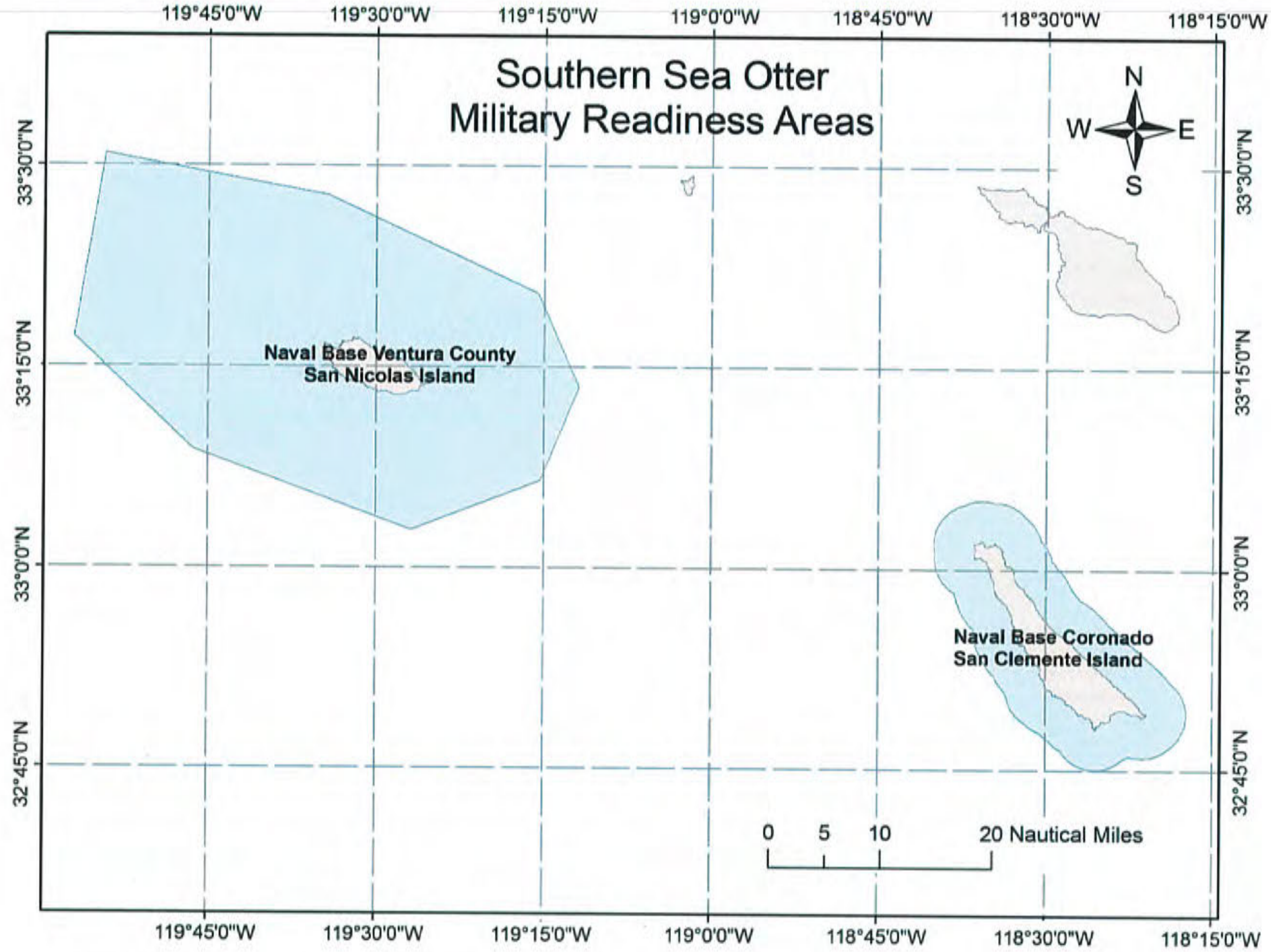
This document contains the research and monitoring plan for the San Nicolas Island Military Readiness Area (SNI Area). Required research and monitoring in this plan are tiered, using population status (increasing, stable, or decreasing) and changes in military readiness activities as triggers for the level of research and monitoring proposed.

Because sea otters do not yet occur at San Clemente Island and may not occur there for decades, preparation of a monitoring plan for the San Clemente Island Military Readiness Area (SCI Area) will not occur until at least three sea otters are present for at least twelve consecutive months or at least one female with a pup is detected. Marine and nearshore natural resource studies and monitoring activities currently occur in the areas around SCI to monitor for other species and habitats of concern. These studies and monitoring events will suffice to detect the presence and persistence of sea otters should they occur in the SCI Area in order to inform at what point a monitoring program under the law will be triggered. This document will be

[1] According to the NDAA, "The term 'military readiness activity' has the meaning given that term in section 315(f) of the Bob Stump National Defense Authorization Act for Fiscal Year 2003 (16 U.S.C. 703 note) and includes all training and operations of the armed forces that relate to combat and the adequate and realistic testing of military equipment, vehicles, weapons, and sensors for proper operation and suitability for combat use."

reviewed by Navy and USFWS every three years after completion of reports to ensure the plan continues to adequately monitor interactions between military readiness activities and the sea otter population.

Figure 1. Southern Sea Otter Military Readiness Areas.



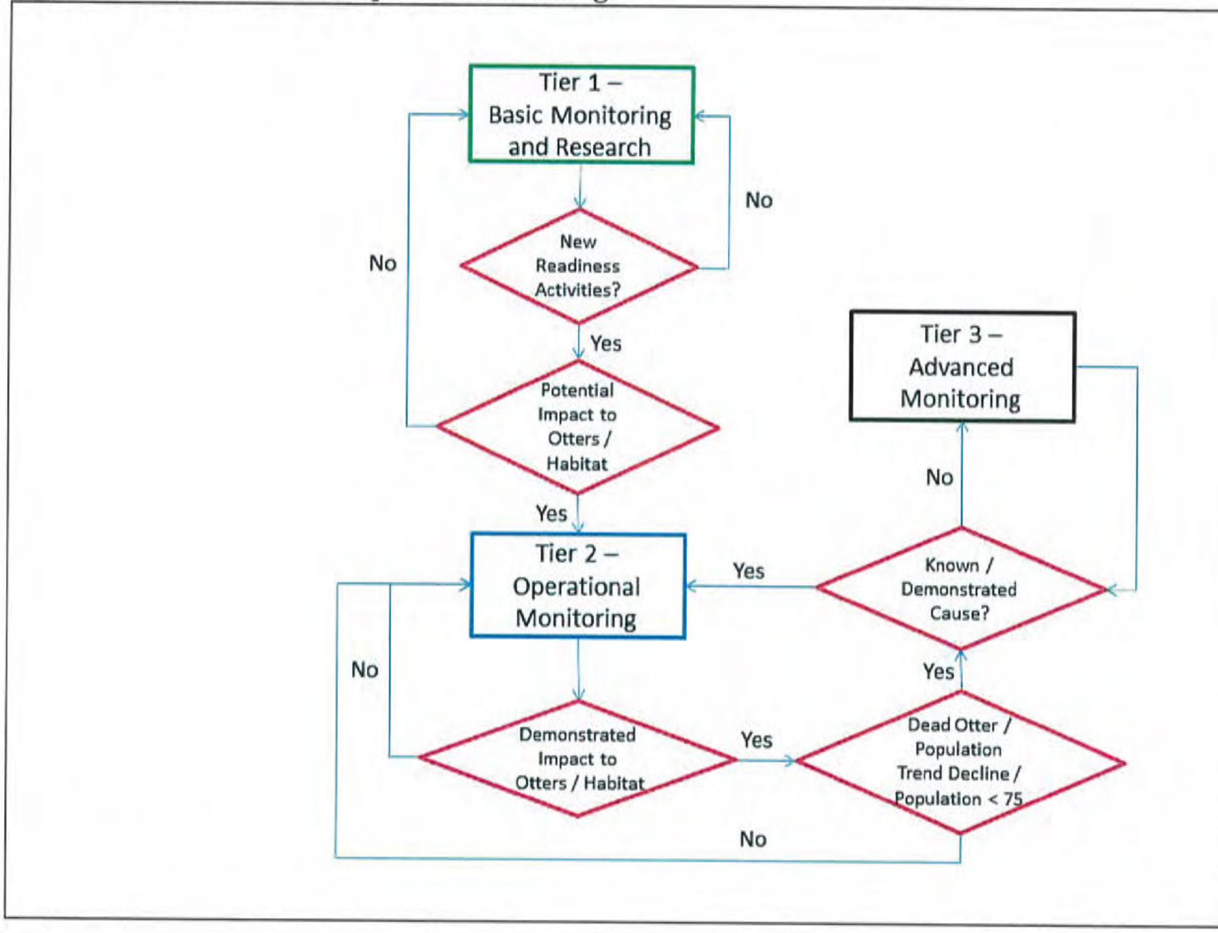
II. MONITORING AND RESEARCH PLAN FOR THE SNI AREA

The monitoring plan outlined below and in Figure 2 contains three tiers. The first tier is Basic Monitoring, which represents monitoring and research required given the current status of the sea otter population and currently occurring military readiness activities. Tier 1 efforts will continue as long as military readiness activities remain constant. The second tier is Operational Impact Monitoring. This higher level of monitoring would be required for any new military readiness activity[2] with a potential to impact sea otters or sea otter habitat. The third tier is Advanced

[2] For the purposes of this plan, a new activity is any activity that would require preparation of an Environmental Assessment or Environmental Impact Statement under NEPA with an area of potential effect within sea otter habitat. Existing activities are described in current NEPA documentation (Appendix 1).

Monitoring, which is triggered if new military readiness activities, as described in Tier 2, are occurring and any of the following conditions is also met: (1) a single dead, moribund, or stranded sea otter with injuries consistent with impacts from the activity (as determined by an independent pathologist) is detected; (2) the sea otter population trend at SNI decreases by more than 10% from the average SNI sea otter population trend over the preceding three-year period[3] for at least two consecutive years for reasons that cannot be reasonably attributed to anticipated density-dependent reductions in growth (see Tier 1, objective 3); or (3) the total sea otter population at SNI drops below 75. If additional funding or outside partnerships allow, Tier 2 and Tier 3 monitoring may occur even if military readiness activities and sea otter population trends remain stable.

Figure 2. Flow Chart of Required Monitoring.



[3] A 10% decrease in population trend would be determined after correcting for observer or measurement error, using State-Space model analysis of the survey time series or comparable method. Using the current average annual population increase of 1.1, for example, a 10% decrease would lead to no increase in population between years (rate of 1.0).

a. Tier 1 Basic Monitoring and Research

1. Objectives for Tier 1 monitoring

The overarching monitoring goal articulated in the NDAA (to determine the effects of military readiness activities on the growth or decline of the southern sea otter population and on the nearshore ecosystem) can be split into four specific objectives that, taken together, will ensure that this broader goal is achieved. These Objectives are:

1. *Monitor and analyze population trends at San Nicolas Island.* Data on trends in sea otter abundance are necessary to assess effects of various stressors on the population. In addition to conducting regular surveys, data will be analyzed using dynamical demographic models to infer baseline population parameters (i.e., annual growth rates and environmental variability). Such data are necessary but not sufficient on their own to determine *causes* of population trends.
2. *Monitor and analyze subtidal benthic communities and assess impacts of sea otter recovery on food web dynamics.* Another core dataset necessary for evaluating impacts on nearshore ecosystem health (with respect to sea otter populations) is monitoring data on benthic subtidal communities, including trends in abundance of foundational species such as kelp and key invertebrates such as urchins and abalone. These data should be analyzed using dynamical multi-species food web models in order to interpret the interacting effects of bottom-up forces (e.g., temperature, wave events) and top-down forces (e.g., increasing predation from sea otters).
3. *Determine the factors affecting population change. Specifically, assess the relative contributions of density-dependent factors (changes in per-capita prey abundance) and density-independent factors (e.g., shark mortality, military readiness activities) to variation in growth rates.* Extensive research on sea otter populations in California has demonstrated that the most common factor leading to localized reductions in population growth is density-dependent resource limitation. The rate of growth of a local population is generally high at low population densities (as has been the case at San Nicolas over the past 20 years) but will slow as populations approach local carrying capacity. The ultimate factor limiting growth is per-capita prey abundance, although resource-limitation may be manifested as increased mortality due to disease and emaciation. Therefore, in order to assess whether some other putative threat is influencing population trends at a given location (e.g., shark bite mortality, entanglement in fishing gear, contaminant exposure, etc.), it is necessary first to account for the role of density-dependent factors. Sea otters are almost unique among marine mammals, in that it is possible to accurately infer population status from a number of easily measured indices, including behavioral parameters (foraging success, percent time feeding), individual body condition, and direct measurements of the abundance and size distribution of key prey species, such as sea urchins. By tracking these indices over time, it has been possible in central California to determine the causal role of density-dependent resource limitation in slowing population growth, and this determination should be even more feasible at San Nicolas due to the existence of better baseline data sets. Achieving this objective will be critical for making a meaningful assessment of the effects of other factors on population growth, including military readiness activities.

4. *Describe habitat use by sea otters at San Nicolas and identify habitats necessary for vulnerable life history stages and behaviors.* Sea otters typically exhibit highly localized patterns of habitat use, which can vary by activity type and by demographic group. For example, resting activity generally occurs in dense kelp canopies, though not all kelp beds are used equally, and certain kelp beds are highly preferred by certain demographic groups (sub-adult males, or females with pups). In contrast, foraging activity more typically occurs along the outer margins of kelp beds and off of emergent rocks. Furthermore, the limited home ranges of most sea otters means that habitat utilization can vary at the scale of kilometers. Understanding home range and habitat use patterns is therefore critical for determining which specific areas around San Nicolas may be most sensitive in terms of the potential for military readiness activities to affect sea otter behavior or health. For example, an area used as resting habitat by reproductive females will be far more sensitive (in terms of the potential to affect population growth) than areas used for feeding by males.

2. Proposed Study Plan for Tier 1 Monitoring

To achieve the above four objectives, a multi-faceted approach consisting of the following tasks is proposed:

Task 1, Objectives 1 and 4. Population Surveys (All Years). An effective survey program for monitoring trends in sea otter abundance at San Nicolas Island is already in place: since the late 1980s, the USGS has annually conducted between two and four island-wide exhaustive sea otter counts, which are compiled in a GIS-compliant data set on abundance and distribution (see Tinker and Hatfield 2015). Surveys are currently conducted twice per year (spring and fall) to provide key data on trends in total abundance and also distribution of sea otters around the island. The frequency of these island-wide surveys would be increased to four times per year for the next four years to provide a higher resolution data set on seasonal variation in distribution and habitat use. These surveys would also provide initial data on important habitat areas around SNI. After four years, power analysis of the existing data can be performed to determine whether reduced effort at two surveys per year will be sufficient for accurate estimation of trends and achievement of other objectives (see Tasks 2 through 4).

Task 2, Objectives 2 and 3. Ecosystem Monitoring (All Years). As with Task 1, subtidal monitoring and kelp canopy monitoring programs are already in place, with twice-annual subtidal surveys conducted by USGS for the past 35+ years (Kenner et al., 2013) and annual kelp canopy surveys conducted by the Navy. For USGS subtidal monitoring, data on the relative abundance of benthic invertebrates, kelps, and fish are collected from seven permanent subtidal sites using standardized SCUBA methods. The resulting data set represents one of the most comprehensive and long-term time series on subtidal ecosystem dynamics worldwide. It can be used to infer the effects of physical disturbance (e.g., large wave events or El Niño conditions) and food-web perturbations (e.g., the recovery of sea otters, disease outbreaks) on community structure and dynamics. For Navy kelp canopy monitoring, multi-spectral kelp canopy images are collected annually via aircraft overflight, processed to determine both surface and subsurface kelp canopy to a 30 cm resolution, and input into a GIS dataset. Subtidal monitoring surveys and kelp canopy overflights would continue at the current frequency.

Task 3, Objectives 3 and 4. Collection of Foraging Data from Untagged Sea Otters (Years 1-2). A number of key indices for determining the population status of sea otters can be assessed from observational data on sea otter feeding. As food resources become more limiting, sea otter diets become more diverse at the population level and more specialized at the individual level, and the average rate of energy gain decreases (Tinker et al., 2008(b), 2012). Two of these indices (diet diversity and rate of energy gain) can be measured using standardized methods for collecting feeding data from untagged sea otters following previously established protocols (Tinker et al., 2008(b)). Earlier studies of sea otter diet and foraging behavior (1987-93, 2004-07), can be compared with current data to determine how sea otter prey choice and foraging success have changed over the last decade. These data will provide one important step towards achieving *Objective 3* and will also allow us to collect baseline data on sea otter distribution, behavior, and habitat use (*Objective 4*). They will also be invaluable for planning future capture and tagging operations, if needed (refer to Tier 3). Foraging data collection will occur concurrently with regular surveys for distribution and abundance (*Task 1*).

Task 4. Data Integration, Analysis, and Reporting (All Years). All field data collected will be entered in a geo-referenced Access database. Population dynamics will be analyzed using published methods to model sea otter populations (Clark and Bjørnstad, 2004; Tinker, 2015; Tinker et al., 2006). Data on sea otter locations and habitat use will be analyzed in GIS using spatial tools and compared with ecosystem and habitat data. Statistical analysis may include logistical regression (habitat use vs availability), Maximum Entropy Models and General Additive Model (GAM). A series of high resolution GIS digital maps will be created to summarize all spatial data and analysis results and to facilitate identification of important habitats for sea otters (habitats most frequently used for feeding and resting).

To evaluate ecosystem-effects of sea otter populations at San Nicolas Island (*Objective 2*), an existing Ecopath mass-balance food web model for sea otters and kelp forests will be modified by combining the dietary data collected during this project and the concurrent subtidal monitoring data (see Kenner et al., 2013), and projections of food web dynamics in response to sea otter predation will be conducted using Ecopath/Ecosim. Community interaction matrix approaches will be used to analyze and forecast food web dynamics. Both approaches will allow us to estimate the range and magnitude of ecosystem services associated with the recovery of sea otters.

b. Tier 2 Operational Monitoring

1. Objective for Tier 2 Monitoring

Operational monitoring under Tier 2 would be required for any new military readiness activity with a potential to impact sea otters or sea otter habitat. At present there are no proposed new military readiness activities with potential to impact sea otters or sea otter habitat and there are no data suggesting continuing activities demonstrate significant disturbance effects. Furthermore, the existence of a measurable disturbance effect would not by itself imply an impact on population growth (indeed, the relatively rapid rate of population growth at San Nicolas Island compared to the mainland population over the past 20 years would suggest that there have been minimal or no effects of disturbance on sea otter populations to date). Rather, the benefit of examining this question would be to provide useful data on the types of disturbance that elicit a response and the contexts in which effects on behavior or energy expenditure are most likely to

occur. Such information could be useful for planning purposes in future military readiness activities and for identifying potential problems before they occur.

1. *Assess the effects of disturbance on behavior and energetics.* In order to determine whether new military readiness activities have the potential to affect sea otter populations, it will be helpful to elucidate the likely mechanisms by which such an effect would occur. Specifically, certain types of activities may elicit a behavioral response (disturbance) and possibly impact individual energy expenditure (depending on the magnitude of response to the disturbance).

2. Proposed Study Plan for Tier 2 Monitoring

To achieve this objective, the following task is proposed for new military readiness activities at SNI with a potential to impact sea otters or sea otter habitat:

Task 1. Real-time Monitoring of Sea Otter Reactions. For any new military readiness activity with a potential to impact sea otter behavior, real-time monitoring of sea otter responses to the activity will occur. To detect behavioral responses and distinguish these from background levels of activity, a "Before-After-Control-Impact" (BACI) design will be used. The BACI experimental design requires sampling to be conducted at both control sites and "impact" (treatment) sites at repeated intervals before and during/after the activities in question. Behavioral sampling will be conducted using one of three methods: (1) If possible, sea otters will be monitored by Navy biologists using high-power telescopes from shore, after receiving training from USGS biologists in standardized scan-sampling methods for measuring the behavior of sea otters. Training will cover basic scan sampling protocols and the categorization of behaviors using standard sea otter ethograms. Note that direct monitoring can occur only if sea otters are present in areas visible by telescope and outside hazard patterns that preclude human presence; (2) Unmanned aerial vehicles (UAVs) may be used to observe sea otters either farther from shore or during events when hazard patterns preclude human presence. UAVs will be equipped with high-resolution video cameras that allow the observation of behavioral changes. In the case of this option, Navy personnel will work with USGS biologists to validate UAV data collection techniques via comparisons with data collected by human observers; (3) If in place, archival data logging tags described under Tier 3 monitoring would replace the previous two methods (see below).

c. <u>Tier 3 Advanced Monitoring</u>

1. Objective for Tier 3 Monitoring

Advanced monitoring would be required in the event that new military readiness activities as described in Tier 2 are occurring and any of the following conditions is also met: (1) a single dead, moribund, or stranded otter with injuries consistent with impacts from the activity (as determined by an independent pathologist) is detected; (2) the sea otter population trend at SNI decreases by more than 10% from the average trend over the preceding three-year period for at least two consecutive years for reasons that cannot be reasonably attributed to anticipated density-dependent reductions in growth (see Tier 1, objective 3); or (3) the total sea otter population at SNI drops below 75. This monitoring would focus on providing a more detailed analysis of habitat use, emigration (if occurring), and reactions to specific activities. If no substantial effect from military readiness activities on sea otter health is detected and a reason for

the declining growth trend is known (e.g., shark bite mortality or food limitation, as substantiated by other monitoring), Tier 3 monitoring would not be required.

After a second consecutive year of change by more than 10% from the current sea otter population trend following the occurrence of new military readiness activities, the Navy will secure funds as quickly as possible to initiate any advanced monitoring requirements. Advanced monitoring will begin when these new funds become available. Advanced monitoring may also benefit earlier objectives, as described, and will be supported prior to the Tier 3 trigger if additional funding or partnerships become available.

2. Proposed Study Plan for Tier 3 Monitoring

To achieve this objective, the following tasks are proposed:

Task 1. Capture, Tagging, and Sampling. In compliance with all applicable Federal laws and statues, a sample of approximately 25 sea otters at San Nicolas Island will be captured and tagged, following methods utilized for many similar studies in the past, including one conducted previously at San Nicolas Island (Tinker et al., 2008(a)). Captures are conducted by a highly experienced and uniquely trained sea otter capture team using specialized closed-circuit SCUBA methods (Ames et al., 1983). Divers swim out from small skiffs, guided by radio transmissions form the skiff operator and shore-spotters, and position underneath a potential resting sea otter. The divers then swim upwards and entrap the resting animal in a Wilson trap attached to an underwater propulsion device. The captured animals are then transported back to a support vessel for processing by a veterinary team.

All captured animals will be anaesthetized and tagged and will receive comprehensive health exams and bio-sampling. Each animal is equipped with colored flipper tags for visual identification, a surgically implanted VHF transmitter for radio tracking, and a time-depth recorder (TDR) for bio-logging of diving activity. VHF frequencies will be deconflicted with Navy working frequencies to avoid any mission impact. Analysis of morphometric data and health parameters, and comparison of these with other sub-populations in California and with previously captured animals at San Nicolas Island (2005-07), will also contribute towards accomplishing Tier 1, *Objective 3*.

Task 2. Telemetry-based Monitoring of Tagged Animals (2Years). After release, study animals will be monitored regularly (using standardized VHF telemetry protocols) by shore-based observers. This phase will continue for two years past tagging (pending support for follow-on work). Field personnel will conduct shore-based daily surveys of the study site using standard telemetric protocols (triangulation on radio signal using VHF telemetry receivers and visual identification using 50-80X Questar spotting scopes: see Tinker et al., 2006, 2008) to locate all study animals within the study area and record precise GPS position, survival, reproductive status, and instantaneous behavior. Attempts will be made to re-sight all study animals at least five times per week. A series of intensive focal-animal observation sessions will be established to collect detailed behavioral data. During these 12-hour focal animal monitoring sessions, data will be recorded at 10-minute intervals on the individual's activity state, diet, dive behavior, distance-to-shore and fine-scale movements (habitat use). Whenever study animals feed during these activity sessions, continuous data will be recorded on dive/surface intervals and prey capture rates and handling times following previously established protocols (Tinker et al., 2008(b)). The anticipated schedule of focal-animal observation sessions is two sessions per

week, with a goal of obtaining three sessions for each study animal. These data, and comparisons with similar data from other populations, provide additional information for characterizing habitat use patterns (Tier 1, *Objective 4*), foraging success and status with respect to prey resources (Tier 1, *Objective 3*), and predator-prey interactions and ecosystem impacts (Tier 1, *Objective 2*).

Task 3. TDR Retrieval and Analysis. After two years of deployment, a second capture operation will recapture previously tagged otters. Recaptured animals will undergo another surgery in order to retrieve the implanted TDR (containing two years of bio-logged diving and temperature data), and a second set of morphometric and bio-health samples will be collected. *Note that at this time a subcutaneous networking tag programmed for short-distance communications and data sharing between otters (and between otters and a buoy equipped with a data retrieval unit) would be implanted.* Data from the retrieved TDR units will be downloaded and analyzed, following established methods, in order to obtain detailed information on time-activity budgets, foraging behavior and diving depth, and reproductive parameters, thereby contributing to Tier 1, *Objectives 3 and 4*. Because the data on behavior have a high resolution (2-second interval between depth readings), it will be possible to relate changes in activity to specific events that occurred over the two-year period, thereby contributing to the Tier 2 objective of identifying reactions to specific events. Existing Navy data on operational dates and times will be used to cross-reference with TDR data.

III. TENTATIVE BUDGETS[4]

Note: The Navy will provide funding for all costs described below. The following budget is divided into expenses associated with implementing Tier 1, 2 and 3. Existing funding for activities already underway is included within Tier 1 expenses (grey highlight).

Tier 1 Budget

Tier 1 Budget Category	Budget Line Item	FY16 Budget Amount	FY17[1] Budget Amount	FY18 Budget Amount	FY19 Budget Amount
USFWS					
Salary	SSO Recovery Coordinator--up to 4 5-day trips/year for data collection w/USGS personnel ($68/hour x 8 hr x 5 days)[1]	$2,732	$10,928	$10,928	$10,928
Travel	Field travel to-from field site plus per diem expenses ($1000/trip)[1]	$1,000	$4,000	$4,000	$4,000
	USFW Sub-total	$3,732	$14,928	$14,928	$14,928
	Indirect Costs @ 22%	$821	$3,284	$3,284	$3,284
	USFWS Total	**$4,553**	**$18,212**	**$18,212**	**$18,212**
USGS					
Salary	Principal Investigator – to oversee project, study design, conduct analyses, finalize reports ($109/hour for 80 hours each year)	$8,720	$8,720	$8,720	$8,720
Salary	Researcher/Project Biologist – to oversee field research and documentation, assist with analysis, and develop reports ($55/hour for 120 hours year 1 and 360 hours years 2 to 4)	$6,600	$19,800	$19,800	$19,800
Salary	Two Research Assistants to support and assist the Project Biologist ($27/hour for 60 hours year 1, 320 hours years 2 to 4)	$1,620	$8,640	$8,640	$8,640
Salary	Additional support for research biologist or graduate sudent to asssist with Food web model development	n/a	n/a	$12,000	$12,000
Materials/ Supplies	Miscellaneous Supplies for sea otter montiroing	$2,000	$1,000	$1,000	$1,000
Travel	Field travel for personnel to-from field site plus per-diem expenses, 3 personnel for 4 data collection field trips of 5 days each	$2,000	$8,000	$8,000	$8,000
Subtidal	Support for Charters, UCSC salary and miscellaneous supplies associated with Subtidal Monitoring, $60K per year[2]	$39,475	$39,475	$39,475	$39,475
	USGS Sub-total	$60,415	$85,635	$97,635	$97,635
	Indirect Costs @ 52%	$31,416	$44,530	$50,770	$50,770
	USGS Total	**$91,831**	**$130,165**	**$148,405**	**$148,405**
USN					
Kelp Canopy	Support for aerial kelp canopy imagery collection and GIS layer compilation[3]	$9,497	$9,677	$9,874	$10,088
	USN Total	**$9,497**	**$9,677**	**$9,874**	**$10,088**
	Tier 1 Total	**$105,881**	**$158,055**	**$176,492**	**$176,705**

[1] Typical involvement is expected to be 1-2 trips/year. FY 16 lower in several areas due to partial year funding. Excess funds will be returned to the Navy.
[2] Current funding of $60 K per year provided by NAVFAC to USGS.
[3] Current funding of $10 K per year provided by NAVAIR contract.

[4] No provision of this plan shall be interpreted as constituting a commitment or requirement that the United States is obligated to pay funds in contravention of the Anti-Deficiency Act, 31 U.S.C. § 1341, or any other provision of law.

Tier 2 Budget

Tier 2 Budget Category	Budget Line Item	FY 1 Budget Amount	FY 2 Budget Amount	FY 3 Budget Amount	FY 4 Budget Amount
Salary	Principal Investigator – to oversee project, study design, conduct analyses, finalize reports ($109/hour for 40 hours each year)	n/a	$4,360	$4,360	$4,360
Salary	Researcher/Project Biologist – to oversee field research and documentation, train and collaborate with Navy biologists, ($55/hour for 80 hours years 2 to 4)	n/a	$4,400	$4,400	$4,400
	Sub-total		$8,760	$8,760	$8,760
	Indirect Costs @ 52%		$4,555	$4,555	$4,555
	Tier 2 Total		$13,315	$13,315	$13,315

Tier 3 Budget

Tier 3 Budget Category	Budget Line Item	FY 1 Budget Amount	FY 2 Budget Amount	FY 3 Budget Amount	FY 4 Budget Amount
Salary	Principal Investigator – to oversee project, study design, conduct analyses, finalize reports ($109/hour for 40 hours years 2 to 4)	n/a	$4,360	$4,360	$4,360
Salary	Researcher/Project Biologist – to oversee field research and documentation, assist PI with analysis, develop reports (55/hour for 1200 hours years 2 to 4)	n/a	$66,000	$66,000	$66,000
Salary	Research Assistant to support and assist the Project Biologist ($27/hour for 1200 hours years 2 to 4)	n/a	$32,400	$32,400	$32,400
Vessel Charter	Support Vessel for Capture operations	n/a	$35,000	n/a	$35,000
Travel	Field travel for personnel to-from captures, plus per-diem expenses	n/a	$10,000	n/a	$10,000
Travel	Field travel for personnel to-from field site plus per-diem expenses	n/a	$25,160	$25,160	$25,160
Equipment	2 VHF tracking receiver	n/a	$2,000	n/a	n/a
Equipment	2 Field Handheld computers for Data Collection	n/a	$2,000	n/a	n/a
Equipment	1 Laptop Computer, data entry	n/a	$2,000	n/a	n/a
Equipment	Buoy/receiver for recording otter network data	n/a	$2,000	n/a	n/a
Materials/ Supplies	Surgical and sampling supplies @ $800 each	n/a	$20,000	n/a	$20,000
Materials/ Supplies	VHF Telemetry tags @ $1000 each	n/a	$25,000	n/a	n/a
Materials/ Supplies	Time Depth Recorders, 15 @ $1200 each	n/a	$18,000	n/a	n/a
Materials/ Supplies	Miscellaneous Supplies	n/a	$5,000	$2,000	$2,000
	Sub-total		$248,920	$129,920	$194,920
	Indirect Costs @ 52%		$129,439	$67,558	$101,358
	Tier 3 Total		$378,359	$197,478	$296,278
	Grand Total - All Tiers	$105,881	$549,729	$387,285	$486,298

IV. LITERATURE CITED

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Appendix 1
List of Current Navy NEPA documents
San Nicolas Island

Document Title	Date	Brief Description
Environmental Assessment Directed Energy Test Facilities at San Nicolas Island	2015 Jun	Directed Energy test facility construction and operations
Environmental Assessment/Overseas Environmental Assessment Point Mugu Sea Range Expansion of Unmanned Systems Operations	2015 Feb	Increased use of both unmanned aerial vehicles and unmanned surface vehicles on the Sea Range
Environmental Assessment Point Mugu Sea Range Countermeasures	2014 Jul	Use of various countermeasures, including guns, directed energy, chaff, flares, and others on the Sea Range
Final Environmental Assessment for Obtaining California Sea Lions for Service in the Navy Marine Mammal Program	2012 Dec	Collection of live sea lions from San Nicolas Island
Final Environmental Assessment/Overseas Environmental Assessment Laser Testing and Training Naval Air Warfare Center Weapons Division Sea Range, Point Mugu, California	2010 Jun	Testing and training with lasers at Point Mugu and San Nicolas Island
Final Environmental Assessment SSM-1 KAI Missile Testing at San Nicolas Island	2007 Mar	Testing and training with Japanese Defense Forces missile system
Environmental Assessment FOCUS Cable Repair – San Nicolas Island, CA	2003 Sep	Repair of undersea fiber optic cable
Arrow System Improvement Program Environmental Assessment	2003 Nov	Testing and training with Israeli Defense Forces missile system
Final Environmental Impact Statement/Overseas Environmental Impact Statement Point Mugu Sea Range	2002 March	Programmatic coverage for Sea Range testing and training activities
Construction and Operation of a Supply Pier on San Nicolas Island	2002 Sep	Pier constructions at San Nicolas Island
Final Environmental Assessment/Overseas Environmental Assessment Harpoon BLOCK II Development Test 2 on the Point Mugu Sea Range	2001 Dec	Testing and training with Harpoon missile systems on Sea Range
Addendum to the EA for Tomahawk Flight Test Operations on the West Coast of the United States	2000 Nov	Addition of a soft-landing area on San Nicolas Island for Tomahawk missile system testing and training.
Final Environmental Assessment - Tomahawk Flight Test Operations on the	1998 Oct	Testing and training with Tomahawk missile systems on

Document Title	Date	Brief Description
West Coast of the United States		the Sea Range
Environmental Assessment Non-warhead Standoff Land Attack Missile (SLAM) Expanded Response (ER) Developmental Test & Evaluation Firings San Nicolas Island, Ventura County, California	1997 Oct	Construction and operation of an inert (non-warhead) target site on San Nicolas Island
Environmental Assessment of the Use of the Outer Sea Test Range for the Shock Trial of The DDG 53	1994 Apr	Shock trial for a specific Navy Destroyer
Environmental Assessment, Fiber Optic Communication Undersea System (Focus)	1989 Mar	Installation of an undersea fiber optic cable between Point Mugu and San Nicolas Island

PROJECT SUMMARY

Overview:

We propose to test for the hypothesized effects of predator diversity on the stability and resilience of kelp forest ecosystems in the face of an ongoing epidemic that has caused coast-wide losses of key sea star species. We will specifically examine the ability of southern sea otters (Enyhda lutris lutris) to compensate for declines in sea stars and use this opportunity to test hypothesized mechanisms by which predators do or do not collectively contribute to the control of herbivores (purple sea urchins and snails) that can otherwise cause phase shifts in kelp forest ecosystems.

Intellectual Merit :

This project will advance our understanding of the combined roles of species diversity and predators in contributing to the stability and resilience of community structure. Though both predators and diversity have been the focus of numerous studies, fewer have explored how predator diversity does or does not enhance the resilience of marine ecosystems. Specifically, elucidation of both the relative importance of direct (mortality) and indirect (prey behavior) trait-mediated effects of predators on prey density and foraging behavior, while simultaneously identifying the mechanisms (i.e. redundancy, complementarity) by which predator diversity determines the strength of this effect is critical to advancing our understanding of the roles of diversity and predation for ecosystem resilience. Dissecting these complex species interactions with unprecedented controlled field experiments to assess their causal relationships at scales relevant to real patch dynamics, combined with field surveys to evaluate their manifestation at scales of the whole ecosystem (kelp forests) collectively constitute the transformative potential of this research. By exploring these species interactions in kelp forest ecosystems, we capitalize on an extraordinary foundation of ecological understanding, hence the rationale for our focus on this system. In addition, the results of this study will inform our understanding of the ecological consequences and reasons for the extent and duration of ecosystem-wide impacts of the current sea star wasting event.

Broader Impacts :

The broader impacts of this study include three elements: graduate and undergraduate training, public outreach, and informing conservation managers and policy makers. Graduate training will be achieved through co-mentoring one graduate student funded directly by this award. To assist graduate students, faculty and researchers in all aspects of the study, we will recruit from a pool of undergraduates with a substantial portion of underrepresented, largely Latino, students. Our outreach efforts will have three main audiences: K-12, the general public, and marine resource managers. Our outreach efforts will target four unique opportunities. We will collaborate with the Monterey Bay Aquarium to facilitate disseminating information about the study and its results through their extensive outreach program, including a huge K-12 educational program. We will collaborate with UCSC?s Broader Impacts Office to pursue outreach avenues such as The Seymour Marine Discovery Center (http://seymourcenter.ucsc.edu/), which provides a conduit to K-12 programs and general public. We will co-develop a video presentation on the project with the Center?s display team. We will use a website and interactive map maintained by one of our associated investigators for tracking the incidence of sea star wasting. Management and policy institutions whose decisions and actions will benefit from the findings of this project include the United States Fish and Wildlife Service (US FWS), California?s Department of Fish and Wildlife (CDFW) and Ocean Science Trust, and federal agencies including The Monterey Bay National Marine Sanctuary (MBNMS), and the USGS Western Ecological Research Center.

Title: Kelp forest community resilience in action: adaptive responses of predators to a disease-driven food web perturbation

Background

Biological communities and the ecosystems they constitute can be remarkably stable, gradually change through time, or exhibit rapid and dramatic changes between markedly different structural and functional states. Explaining and predicting these dynamics are fundamental goals of ecology with great implications for conservation and management. The capacity to explain and predict system dynamics requires knowledge of the biotic and abiotic processes that determine community structure (i.e. species composition, richness and evenness), and functions (i.e. interactions among species and their environment that determine energy/nutrient dynamics). There are now many examples demonstrating how species interactions can have profound influences on the structure and functioning of marine communities and contribute to their resistance and resilience to biotic (e.g., harvesting, disease, invasion) and abiotic (e.g,, storms, El Nino, habitat loss, hypoxia) perturbations (*1–6*). Collectively, these studies emphasize the separate and substantial effects that higher level predators (*7–24*) and changes in biodiversity (*3*, *5*, *25–27*), can have on the structure, functioning and stability of marine communities. However, how diversity of key consumers influences the structural and functional attributes and the resistance and resilience of marine ecosystems is less well understood (*17*, *28*, *29*).

The role of biodiversity and mechanisms by which species and functional diversity imparts resistance and resilience and enhances ecosystem productivity has received great attention (*2–6*, *30–38*). Two mechanisms by which diversity enhances these ecosystem attributes are redundancy and complementarity (*39*). Redundancy occurs when species that contribute similar functional roles yet differ in their responses to environmental variation and perturbations, compensate for one another, thereby maintaining ecosystem functionality. Complementarity is the enhancement of one species' function by the presence of other species. Greater species diversity increases the likelihood that both of these mechanisms will be observed within a community, the so-called "sampling effect" (*40*). While these concepts identify mechanisms by which diversity and species interactions contribute to system resistance and resilience, their application for predicting system responses requires knowledge of the relative strengths of species interactions, how species interact and respond to changes in density, and how these interactions vary with different or changing environmental conditions and forms of perturbation (e.g., physical or biological).

Because of their great species richness, productivity and accessibility, kelp forests (laminariales) in temperate oceans throughout the world have attracted ecologists exploring how species interactions influence community and ecosystem dynamics. Kelp forests exhibit a diversity of dynamics, with some forests persisting for decades, others exhibiting strong interannual variability, and others demonstrating rapid shifts from forested to barren states that can persist for decades (*41–59*). Such dynamics also exist within forests, creating mosaics of asynchronous patches in various states of community structure (*41*, *43*, *44*, *46*, *55*, *60*). These dynamics are thought to reflect the combined effects of physical forces (ocean waves that remove portions or entire forests) and variation in grazing intensity associated with changes in the abundance and foraging behavior of sea urchins (*41*, *47*, *48*, *52*, *55*, *56*, *58*, *59*, *61–69*) reviewed in (*53*, *54*, *70*, *71*). The persistence of alternative states appears to be influenced by positive feedbacks; overgrazing by urchins both reinforces their intensive grazing behavior (*47*, *54*, *72*) and facilitates their own recruitment (*73*). In addition, grazing gastropods may contribute to mortality of gametophytes and sporophytes of kelps (*49*, *74*).

The vast majority of studies that have examined how species interactions influence the state of kelp forests suggest that specific higher-level predators can have marked influences on forest

dynamics (reviewed by (*54*, *71*, *75*). For example, studies of sea otters, *Enhydra lutris*, in kelp forests along the Aleutian archipelago (*76–80*) and Vancouver Island, Canada (*58*) revealed how trophic cascades generated by these apex predators can control the structure of these forest communities. When otter densities were reduced through human exploitation or orca predation, otters were unable to control the behavior and abundance of their prey, herbivorous urchins, allowing these systems to shift from forested to barren reefs (devoid of macroalgae) (Estes et al 1998). At smaller spatial scales, patchy distribution of the sunflower star, *Pycnopodia helianthoides*, in Alaskan forests create mosaics of forested and barren reef patches altering the structure and productivity of the system (*81*). California sheephead, *Semicossyphus pulcher*, are urchin predators in *Macrocystis* forests along the coasts of southern California and Mexico (*69*, *82–85*) and urchin density, size structure and foraging rates can be inversely related to sheephead density (*69*, *83*, *85*, *86*). Large size classes of spiny lobster can likewise control the density and size structure of urchins in *Macrocystis* forests of Tasmania. Where the size structure of lobster is reduced by commercial fishing, urchins achieve size refuge and forests are replaced by barrens (*87*). Similarly, in *Macrocystis* forests in southern California, the California spiny lobster (*Panuliris interruptus*) can be an important predator on purple and red sea urchins (*51*, *82*, *88*, *89*), though their effects appear to vary geographically (*90*, *91*). The extent to which the cascading effects of any one of these urchin predators determine the spatial and temporal variation in kelp abundance continues to be debated among ecologists. While these studies suggest the importance of individual predators in determining the dynamics, structure and functions of kelp forests, they also implicitly assume that loss of these species are not compensated for by alternate (functionally redundant) predators. Thus, while such predators are particularly vulnerable to natural and anthropogenic losses, the consequences of predator diversity in controlling grazing effects and contributing to the resistance and resilience of forest ecosystems remains poorly understood (*29*).

Predator diversity can influence the strength and direction of species interactions, including trophic cascades, by either dampening (*92*) or magnifying (*93*) their effects. For example, Byrnes et al (*93*) found that diversity (not density) of predators at lower trophic levels was negatively correlated with herbivore abundance and positively correlated with kelp abundance. These results were corroborated by mesocosm experiments and also revealed that predator effects involved behavioral responses of prey that dramatically altered their grazing rates. That study and others (*47*, *83*, *86*, *94*, *95*) lend evidence for strong indirect trait-mediated effects of predators in altering the distribution and foraging behavior of urchins and contributing to resistance and resilience of kelp forests. Indeed, the role of trait-mediated (especially behavioral) influences of predators may be a particularly important mechanism of trophic cascades (*96*, *97*). As such, and contrary to the majority of studies indicating the importance of particular predators, predator diversity may enhance the effect of each predator species in controlling grazers, because a more diverse suite of predators feeds more efficiently across all size classes of urchins (i.e. complementarity) or one predator can compensate for the loss of another (i.e. redundancy). Both of these mechanisms may involve direct (mortality) or indirect (foraging behavior) responses of their prey (urchins).

In central California, southern sea otters (*Enhydra lutris nereis*, hereafter “otters”) are important predators of sea urchins (*98*, *99*) and the almost ubiquitous low densities of urchins in this area is assumed to reflect their presence (*59*, *98*, *100*). Otters are voracious predators that consume 25-33 percent of their body weight per day (*101*) and whose diet includes urchins as well as a diverse array of benthic invertebrates (*98*, *102*). Although diet diversity is high at the population-level, individual otters in resource-limited areas tend to specialize on a just few prey types (*99*, *103*), and so urchins (when they are at low abundance) are mostly consumed by urchin specialists.

However, examples of marked changes in urchin abundance independent of otters also exist (*61*, *62*, *104*), and otter access to local (patch-scale) populations of urchins has never been manipulated to evaluate the rate and magnitude of mortality attributable to their predation. Another potentially important urchin predator in the central coast, the sunflower star (*Pycnopodia helianthoides*, hereafter *Pycnopodia*) feeds on smaller sea urchins and a diversity of herbivorous gastropods (e.g., *Promartynia pulligo*, hereafter *Promartynia* or snails) (*62*, *63*, *81*, *82*, *93*, *105*). Another particularly abundant carnivorous sea star, the giant sea star (*Pisaster giganteus*, hereafter *Pisaster*) forages on sessile and mobile invertebrates, including a diversity of carnivorous and herbivorous gastropods (*74*, *106*, *107*). However, over 1000 diet samples of *Pisaster* produced zero urchins (*108*), suggesting that influences of *Pisaster* on urchin foraging rates is more likely to be a predator avoidance response. Thus, understanding the separate and combined (additive or multiplicative) effects of these sea stars and otters in controlling urchin density and foraging behavior is central to understanding how predator diversity affects the resistance, resilience and productivity of kelp forest ecosystems.

In 2014, several species of intertidal and shallow subtidal sea stars experienced an epizootic (viral or bacterial disease) that has led to widespread declines in the abundance of several species of sea stars (*109*). Across the West Coast of North America from Alaska to Mexico, populations of intertidal (*Pisaster ochraceus*) and subtidal (especially *Pycnopodia* and *Pisaster giganteus*) sea stars have experienced local extinctions, including those species previously implicated as "keystone" predators that disproportionately influence the structure and functions of their ecosystems relative to their abundance (*81*, *110*, *111*). Already, densities of both purple, (*Strongylocentrotus purpuratus*, hereafter "purple urchins"), and red urchins (*S. franciscanus*, hereafter "red urchins"), have increased beyond typical densities (Figure

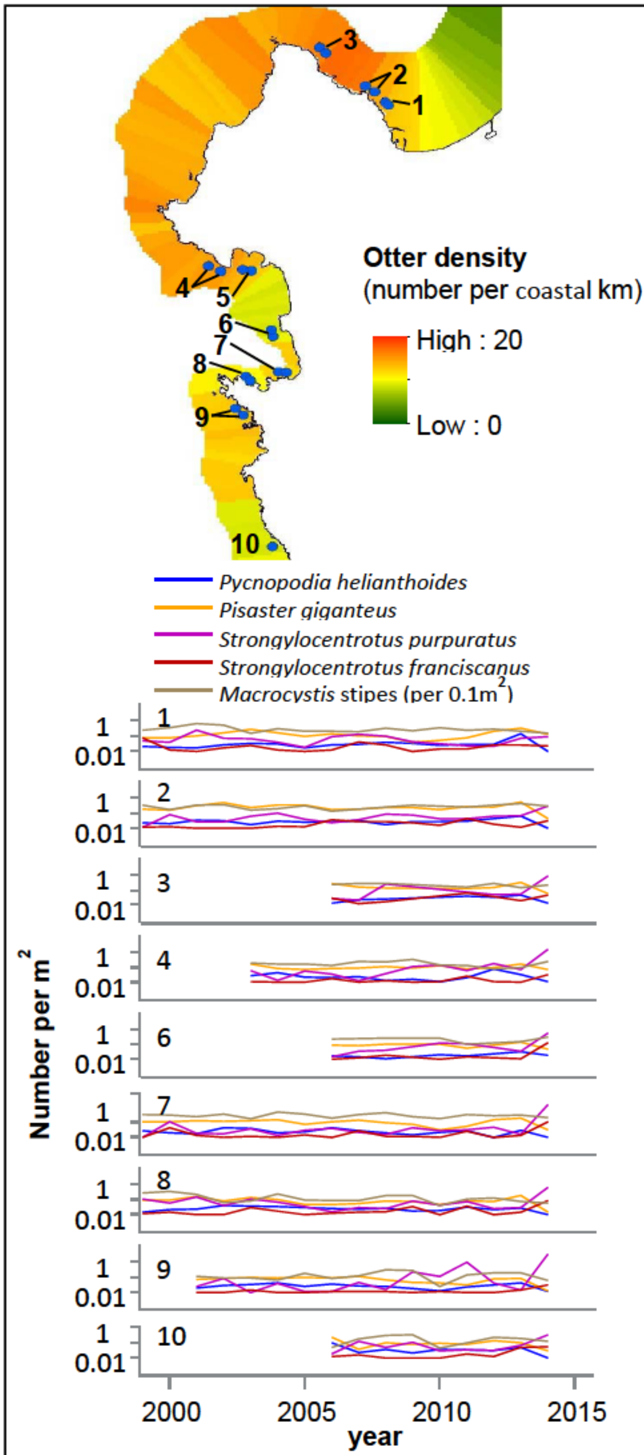

Figure 1. Otter densities and temporal patterns of sea star (*Pycnopodia helianthoides* and *Pisaster giganteus*), sea urchins (*Strongylocentrotus franciscanus* and *S. purpuratus*) and giant kelp (*Macrocystis*) stipes from sites surrounding the Monterey Peninsula during the period 1999-2014. Density estimates represent mean of 6-12 transects per site.

1). Over the 16 years and 10 sites surveyed around the Monterey Peninsula, annual change in density (log ratio of one year to the next) of purple urchins was inversely related to change in *Pisaster* and *Pycnopodia* (R^2=0.1144, P<0.0001 and R^2=0.0852, P<0.0001, respectively). In contrast, a weak relationship was detected between annual changes in density of red urchins and *Pisaster* (R^2=0.0313, P= 0.0303), and no relationship was detected between red urchins and *Pycnopodia* (R^2=0.0038 , P= 0.4529).

Although densities of giant kelp, *Macrocystis pyrifera,* have not yet decreased as predicted by the trophic cascades identified in the many examples summarized above (Figure 1), the occurrence of patchy barrens, rarely seen over the 15 year history of surveys conducted throughout central California kelp forests, have been noted (personal observations). Based on these observations and expected time lags in the dynamics of both urchins and kelps to declines in sea star predators, marked declines in kelp density and shifts from forested to barren reefs are predicted. As such, the current sea star epizootic presents a very unique and timely opportunity to explore whether and how the diversity of key urchin predators may buffer ecosystems to this perturbation.

Initial increases in recorded numbers of red and especially purple urchins across all size classes suggest that the apparent increase in densities reflect a trait-mediated behavioral response. As observed in the several studies described above, increases in densities of larger size classes implicate a shift in urchin behavior that has led to their greater detection on surveys (Figure 2). Rapid increases in the larger size classes of purple urchins observed in 2014 can't be explained by numerical responses (i.e. recruitment) or increased survivorship; numbers of larger purple urchins observed in 2014 exceed the sum of the that size class (100% survivorship) and then next three smaller size classes from the previous year (typical mean growth rates of purple urchins are roughly 1-3 cm per year in central California; (*62*, *112*, *113*). In contrast, increases in the smallest (3 cm) size classes may reflect combined numerical (recruitment from smaller size classes) and behavioral responses. The observed increases in densities across all size classes of purple urchins suggest (i) responses to observed declines in sea star predators, and (ii) that significant levels of compensatory predation by otters on purple urchins have yet to be realized.

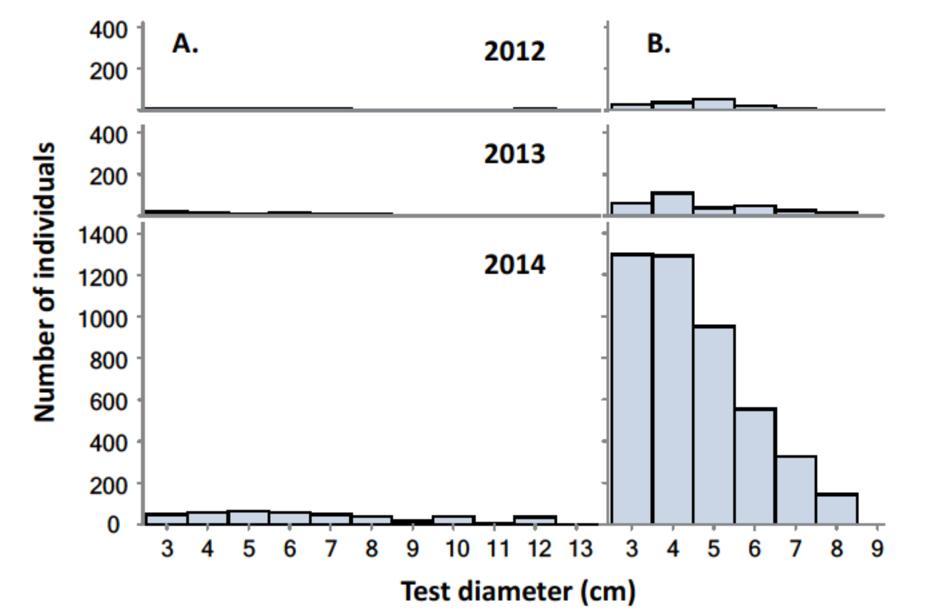

Figure 2. Size frequency distribution of (a) red sea urchins and (b) purple sea urchins observed on survey transects at sites identified in Figure 1 over the period 2012-2014.

Therefore, we propose to test several general hypotheses germane to the questions of whether

and how predator diversity (i.e. the presence of alternative predators) may buffer communities and ecosystems to perturbations. We draw from the ongoing biotic perturbation (epizootic) that has led to dramatic declines in populations of sea stars and explore the potential role of otters to buffer population responses of urchins that may otherwise lead to dramatic shifts in the structure and functions of kelp forest ecosystems in Central California.

Proposed Research to be Undertaken

Given this background, in this study we will address the following eight questions. Questions one through four will be addressed using experimental orthogonal manipulations of predators (otters, *Pisaster, Pycnopodia*) to observe the response of prey (purple urchins, *Promartynia*), and algae (*Macrocystis*). Question five will be addressed using kelp forest ecosystem surveys, and questions six through eight will be addressed using radio-tagging and observation of otters.

1) Predator effects on density and size of exposed prey. What are the separate and combined effects of otters and *Pisaster* or *Pycnopodia* on the density and size structure of *exposed* (i) purple urchins, (ii) *Promartynia* snails and (iii) young *Macrocystis* plants? *Exposed* urchins and snails are those not confined to crevices, reflecting active grazing and vulnerability to predation. Counts of exposed individuals in the orthogonal predator manipulations will indicate combined direct (mortality) and indirect trait-mediated (behavioral) predator effects.

2) Direct and trait-mediated effects of predators. What are the relative contributions of mortality (density effects) and behavioral responses (trait-mediated effects) to changes in the density of *exposed* urchins in response to the presence of predators (otters, *Pisaster* or *Pycnopodia*)? Evidence suggests that urchin responses to *Pisaster* are largely behavioral (not direct mortality) whereas responses to *Pycnopodia* and otters include both urchin mortality and behavior. These will be teased apart by distinguishing changes in density and size structure of exposed versus total urchins and snails in the orthogonal predator manipulations.

3) Redundant versus complementary predator effects. Do the different predators (otters, *Pisaster* and *Pycnopodia*) contribute differentially to reduced numbers of exposed prey (purple urchins and snails) of different size classes, reflecting complementarity among these predators across the size distribution of urchins and *Promartynia*? Because otters feed solely on larger size classes of urchins, control of urchin populations might be a function of sea star predation on smaller size classes and otter predation in larger size classes. This will be tested by comparing size frequency distributions of surviving urchins across the orthogonal manipulations of predator access, and combining these data with observational data on size-dependent consumption rates by tagged otters.

4) Cascading predator effects on kelp. Are the separate and combined effects of predators (otters, *Pisaster* and *Pycnopodia)* on the density and size structure of *exposed* purple urchins (based on combined numeric and trait-mediated responses) manifest in changes in mortality rate and density of young *Macrocystis* plants, reflecting a trophic cascade?

5) Larger scale manifestation of predator effects. Are the direction, strengths and mechanisms (mortality versus behavior) of predator-prey interactions, including the hypothesized three-level trophic interaction revealed in the controlled orthogonal experiment, manifest over time and among sites distributed across the study region? To test hypothesized spatial and temporal correlations in density and size structure) of prey (urchins, *snails*) and kelp (*Macrocystis* and other macroalgae) to variation in predator density (otter, *Pisaster*, *Pycnopodia*), we will conduct annual surveys across ten sites distributed across the study region. These results will indicate whether conclusions generated by the experiments (i) “scale-up” to explain variation in the structure and dynamics among kelp forests along the coast, and (ii) are robust to the environmental (reef structure, oceanography) and biotic (overall community structure) variation in these kelp forest ecosystems.

6) Sea otter behavioral responses. Does the rate of predation on and relative contribution of purple urchins and *Promartynia* in the diet of otters increase in response to declines in sea

star densities and increases in density of urchins and snails, as compared to "normal" variation in dietary prevalence over the past 15 years?

7) Co-variation of predators and prey. Is there spatial variation in the dietary response of sea (rate and success) and does this correspond to spatial variation in prey density (exposed urchins and *Promartynia*)?

8) Effect of individual specialization. Do spatial and dietary response vary predictably among individual otters based on historic and current patterns of dietary specialization? That is, does increased dietary prevalence of urchins and/or snails occur similarly for all otters, or is it only evident (or most pronounced) for urchin/snail diet specialists?

Approach:

We propose to answer the questions posed above with a combination of field experiments, ecosystem surveys, and telemetry-based studies. These methods will enable us to examine the consequences of reduced rates of sea star predation on urchins at two spatial scales. Experimental manipulations will identify causal effects of relative rates of predation at the scales of (6m^2) patches. Surveys conducted at ten sites over three years will identify spatial and temporal correlations among sea star, otter and giant kelp densities across natural variation in densities of these species as well as environmental conditions (reef structure, wave exposure). Observational data collected from radio-tagged otters will provide longitudinal information on variation in otter diets both at the population and individual level. Surveys and otter observations will evaluate the extent to which causal responses identified at the patch scale do or do not scale up to site level.

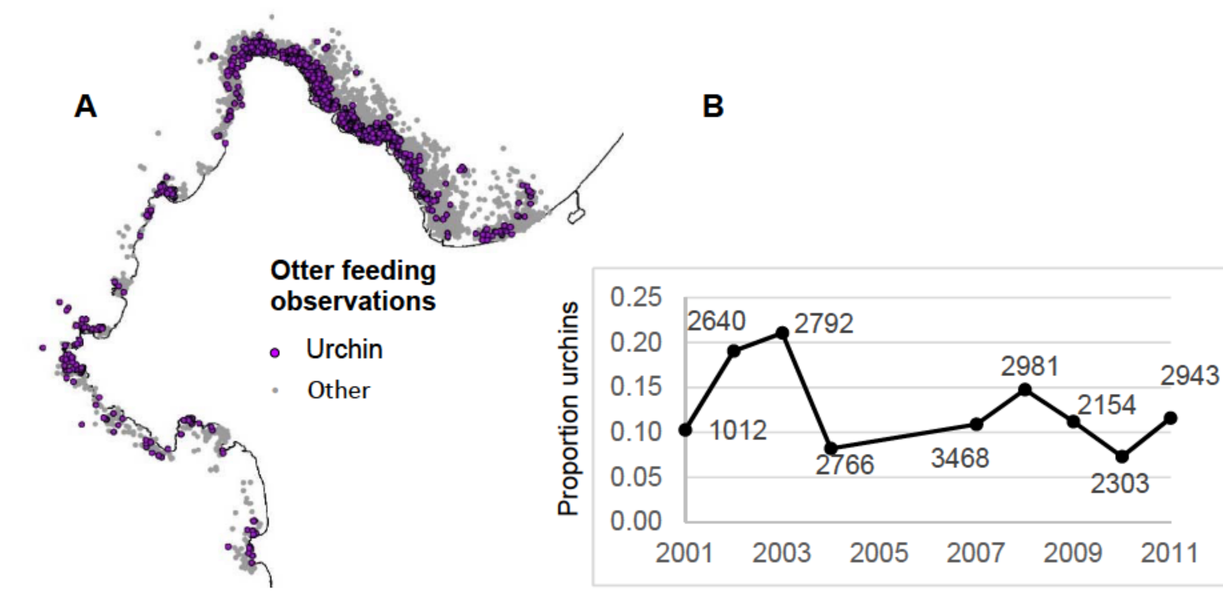

Figure 3 (A) Distribution of sea otter foraging activity: purple points indicate observations of otters feeding on urchins. **B**) Proportion of total feeding observations in which otters fed on urchins in the study region. Values indicate sample size (number of observations).

Orthogonal manipulation of urchin and snails predators

We propose to deploy 24 6m^2 cages designed to orthogonally manipulate the access of otters with access of either *Pisaster* or *Pycnopodia* to a size range of purple urchins and *Promartynia*. Orthogonal manipulations of otters and *Pisaster*, and otters and *Pycnopodia* will be conducted separately in year 1 and year 2 of the project, respectively. Depending on the rate of responses of predators and prey, Year 3 is a buffer for each of these experiments. Otherwise, a third

experiment orthogonally manipulating the two sea star species or prey (urchin) density refuge availability will be conducted.

Cage design: All 24 cages will be deployed at a depth of 10-12 m along a section of the northwest face of the Monterey peninsula where a history of otter foraging rates and behavior have been collected (Figures 1 and 3). Cages are 2m by 3m (6m^2) rectangles of 0.75 m height (Figure 4). The mesh is standard 11.5 gauge galvanized metal cyclone fencing (5cm x 5cm square mesh) and the structural supports are standard 4cm diameter galvanized steel cyclone fencing posts and three-way joints. All 24 cages have cyclone fencing walls, a cyclone fencing bottom and 10cm horizontal lips. The bottom, walls and lips of all 24 cages are lined with 1 cm sq galvanized mesh (hardware cloth) to prevent prey (urchins and snails) and sea stars from entering or leaving the cages. This allows us to control prey and sea star densities over the duration of the experiments. The 12 cages designed to exclude otters have two panels of cyclone fencing that enclose the top and are removable to allow divers to survey exposed urchins and snails. Top panels are secured to the horizontal supports at the top of the walls by heavy duty (1cm wide) plastic cable ties. The 12 cages designed to allow access of otters have no top. Horizontal lips at the top of the vertical walls are designed to prevent sea stars, urchins and snails from entering or leaving the cages, but tips of these horizontal lips may be painted with copper-base paint if necessary.

Reef habitat: To weight cages to the bottom and to standardize heterogeneity of the reef structure (i.e. visual detection of exposed prey and availability structural refuge for prey) rock boulders will be placed inside the cages. Size frequency (diameter) and shape of boulders will be similar across all 24 cages. The amount of rock habitat across all cages will be similarly adjusted to ensure sufficient structural refuge for the number of prey in each cage. This is required for the assessment of behavioral versus density responses to predator treatments (Question 2).

Spatial design: Six replicate cages of four orthogonal treatment levels (- otters -star; -otter +star; +otter -star; +otter, +star) will be spatially blocked with random placement of each treatment level per block. The design assumes that otters will access the two “otter accessible” treatment levels, based on the perceived influence of otters on urchin densities in the study region, the large number of otter-urchin feeding observations at the experimental site (Figure 3) and the relatively large area (6 m^2) of the cages. To test this assumption, a time lapse video recorder (GoPro) will be deployed at each block of four cages to monitor the frequency of otter access. Cages will be separated by a minimum of 5m to reduce the likelihood that predators will influence the behavior of prey in adjacent cages.

Prey manipulations: Natural densities and size structure of purple urchins and *Promartynia* snails will be established within cages at the onset of each experiment. Urchin dispersion is extremely patchy and our past surveys in the study region have detected upper densities of 15 per m^2 (= 90 per 6m^2 cage). Size frequency distributions of purple urchins are extremely variable, but using the distribution depicted in Figure 2 and making no size class less than 10 individuals, we will stock each cage with 22 3cm, 22 4cm, 16 5cm, 10 6cm, 10 7cm, and 10 8cm test diameter purple urchins. Watanabe (*74*) estimated mean density of adult *Promartynia* at 4 per m^2 and 40 per m^2 on rock bottom and kelp, respectively, and juvenile (< 16mm dia) *Promartynia* at 3 per m^2 and 227 per m^2 on rock and shell rubble habitat, respectively, at 12 m depth in southern Monterey Bay. Given this great variability, we will seed each cage with 60 *Promartynia*, allocated across three size classes: 30, 20 and 10 individuals in 1±0.5, 2±0.5 and 3±0.5 cm basal diameter. These size distributions of both urchins and snails reflect variation in natural size structure, to better mimic effects of encounter rates on a predator’s size selection,

but also increase numbers of larger size classes to characterize the observed changes in size distributions described above and avoid proportional inflation of loss of few individuals. Prey will

be placed in cages and cages will be covered with top panels for a 24 hrs acclimation period prior to adding or allowing access of predators. Using techniques described in Pearse and Pearse (*112*), all purple urchins added to cages will be treated with injections of tetracycline to mark the initial diameters of their tests. This will allow us to identify growth of individuals and immigrants to the cages by collecting and sampling all individuals at the end of the experimental trials.

Effect of grazer density and behavior on kelp survival: To determine the effect of changes in urchin and snail density and behavior on the survival and size structure of *Macrocystis*, we will add similar size rocks containing young *Macrocystis* plants to every cage. Reed and Foster (1984) recorded 9.6± 1.4 young *Macrocystis* recruits per m^2 in a forest on the Monterey peninsula. Recruitment is very patchily distributed, so we will distribute 10 (0.25m dia) rocks with six small (single stipe, 5-10cm height) *Macrocystis* plants each (total 60 plants) per cage. Rocks with young *Macrocystis* recruits are abundant at the proposed experimental site.

Sampling: One block of four cages will be sampled each day (all four blocks each week) for the duration of the study. Each sample, the number of exposed urchins and *Promartynia* will be counted and measured. Depending on the rate of change of treatment levels exposed to

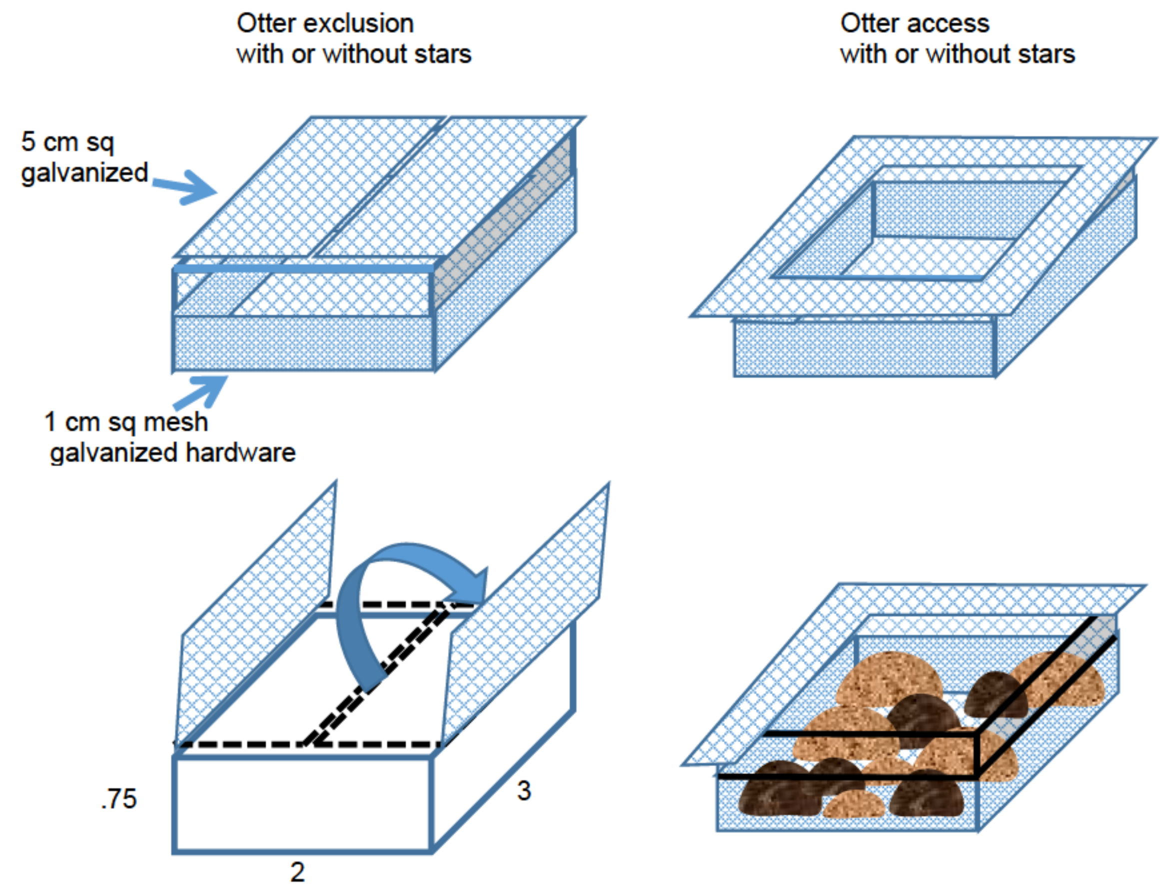

Figure 4. Predator exclusion/inclusion cages designed to (a) exclude sea otters with or without sea stars, or (b) allow access by sea otters with or without sea stars. Horizontal lips atop walls of otter accessible cages impede urchins, snails and stars from migrating in or out of cages. (c) Removable panels on otter exclusion cages allow divers to count and measure exposed and hidden sea urchins, snails and kelp. (d) Rocks are placed inside cages to standardize visual detection and refuge for prey, including rocks with young kelp.

predators, a total count of individuals (exposed and hidden) will be made at a frequency of two weeks (every other survey) to estimate the trajectory of the relative abundance of exposed and hidden individuals. More frequent estimates of total individuals will be made if declines in number of exposed individuals are rapid, less frequent if the decline is slow. The lower frequency of estimates of total number is to minimize the disturbance of searching for hidden individuals during the experiment. The number and height of each *Macrocystis* plant will be recorded on each survey.

Tests of hypotheses:

1) Predator effects on density and size of exposed prey. Density (number per cage) responses of exposed urchins, snails and kelp plants will be estimated as both the (i) slope of the decline in numbers per cage recorded weekly over the duration of the experiment, and (ii) comparison of final numbers of exposed individuals among treatment levels at the end of the experiment. The relative **separate** effects of predators are determined by comparing prey declines in each single-predator with no-predator treatment levels and comparing these differences between predators. Rates of decline and final densities will be compared among treatment levels with general linear model approaches (e. g., analyses of covariance – ANCOVA and ANOVA, respectively), assuming parametric assumptions are met. If not, we'll use a generalized approach. The **combined** effects are determined by comparing rates of decline and final densities observed in single-predator and two-predator treatments. The interaction term in these comparisons will be used to test for non-additive effects of predators. Signification interactions between pairs of predators may be positive (facilitated rates of predator foraging efficiency) or negative (interference between predators) (*114*, *115*). Separate and combined effects of predators on prey size structure will be tested similarly by comparing prey size distributions between no-predator, single-predator, and two-predator treatments. Differences in size distributions will be tested among the weekly samples and at the end of the experiment using a generalized linear model with a log-linear function. Comparison of changes in size structure over time between predator treatments indicates the relative predation rates on different size classes of prey. These differences will be evaluated by decomposing the model to test for the interactions among size (binned into the classes described above), time (weeks), and predator treatment levels. We predict differences in effects of predators based on their known selective foraging (e.g., otters on the largest size classes versus *Pycnopodia* on smaller size classes) and direct versus indirect effects (e.g., behavioral responses to *Pisaster* are likely to be greater for smaller urchins and more uniform across all size classes of snails).

2) Direct and trait-mediated effects of predators. Evidence suggests that urchin responses to *Pisaster* are largely behavioral (not direct mortality) whereas responses to *Pycnopodia* and otters include both mortality and behavioral responses. These will be teased apart by distinguishing changes in density of exposed versus total (exposed plus hidden) urchins and snails in the orthogonal predator manipulations. To avoid nonlinear responses due to limited refuge availability, we will determine that sufficient refuge is available for all prey at the beginning of the experiment, by using crushed urchins to elicit a refuge-seeking response and searching for any remaining exposed individuals. Crushed conspecifics elicit a very strong refuge seeking behavior in urchins (*58*). To test the hypothesis of differences in the relative contribution of direct density effects (mortality) and behavioral responses of exposed prey among the three predators, we will compare the relative rates of change in exposed vs. total prey among the four treatment levels. For example, we predict that any change in the relative frequency of exposed urchins over time would be attributed almost entirely to behavioral responses and little, if any, to mortality. Hence, the (negative) slope of exposed urchins over time would be significantly greater and different than the change in total number (i.e. time by response interaction). Because *Pycnopodia* would be an ever-present voracious predator of urchins and snails, we predict a significant decline in both exposed and total density, though the (negative) slope of decline in exposed individuals should still be greater than total number

because of a refuge effect. Because otter predation is episodic and possibly more thorough (turning of rocks) the rate of decline in total numbers and exposed numbers will be more similar to one another. These responses may well be non-linear. Generalized linear models (GLM) will be used to compare slopes between behavioral and density responses, between prey (urchins and snails) and between predators to evaluate how the relative strengths (contributions) of the behavioral and density effects vary by species of prey and predator.

3) Redundant versus complementary predator effects. Because otters feed solely on larger size classes of urchins, control of urchin populations might be a function of sea star predation on smaller size classes and otter predation in larger size classes. This will be tested by comparing size frequency distributions of surviving urchins across the orthogonal manipulations of predator access. As described in Question (1), differences in size distributions will be tested among the weekly samples and at the end of the experiment using a generalized linear model with a log-linear link function. Comparison of changes in size structure over time between predator treatments indicates the relative rates at which they influence the different size classes of prey. These differences will be evaluated by decomposing the model to test for the interactions among size (binned into the classes described above), time (weeks), and predator treatments to determine if the combined effects of both predators are additive or multiplicative on each size class.

4) Cascading predator effects on kelp. The cascading effect of predator control of grazer density and behavior is manifest in the survival and size of the foundational species, *Macrocystis*. Change in kelp density from those established at the onset of the experiment will be compared among the four predator treatment levels with general linear model approaches, assuming parametric assumptions are met, or generalized linear model, as described for Question (1). Differences in size distributions will be tested among the weekly samples and at the end of the experiment using a GLM with a log-linear link function. Comparison of changes in size structure over time between predator treatments indicates the relative rates at which they influence the different size classes of kelp. These differences will be evaluated by decomposing the model to test for the interactions among size (measured to the centimeter and binned into size classes depending on growth rate), time (weeks), and predator treatment levels. We predict that declines in kelp density will be greatest in cages excluding all predators, and least likely in the presence of both otters and *Pycnopodia*. Intermediate reductions may occur in the presence of *Pisaster*, however as in all cases of combined predator treatments, this depends on whether predator interactions are positive (facilitated rates of predator foraging efficiency) or negative (interference between predators).

5) Larger scale manifestation of predator effects. To test hypothesized spatial and temporal correlations in density and size structure (generated from the experiment) in prey (purple and red urchins, snails) and kelp (*Macrocystis* and other macroalgae) to variation in predator density (otter, *Pisaster*, *Pycnopodia*), we will conduct the annual surveys described below across 10 sites distributed across the study region.

Community surveys

We will conduct kelp forest community surveys at ten sites distributed throughout the Monterey Peninsula study region in order to (1) characterize the progression of predator (*Pisaster* and *Pycnopodia*), grazer (purple and red urchins, *Promartynia* and other herbivorous and detritivorous gastropods) and algae (*Macrocystis*, other kelps and foliose red algae) population dynamics, and (2) determine whether species interactions revealed in the caging experiment are manifest at the larger spatial scale of forests and the greater natural variability of environmental (biological and physical) conditions among forests. Survey sites include those for which we have a long-term (9-16 year) baseline characterization of community structure prior to at and at the onset of the sea star wasting epidemic (Figure 1). These sites also include baseline characterizations of otter density and foraging behavior (see below). At a subset of these sites, continued otter surveys will allow us to (3) determine how otter distribution and

foraging behavior respond to changes in prey (urchin and snails) and alternative predator (*Pisaster* and *Pycnopodia*) densities estimated by the benthic community surveys.

Each survey "site" is comprised of two halves side by side along the shoreline, in which two 30m long x 2m wide swaths are located along each of three isobaths (5m, 12.5m and 20m depth) from the inshore to the offshore width of the forest. Surveys will be conducted annually (July-early September) at each site in each year of the study period. Details of species lists and sampling protocols are available at http://www.piscoweb.org/research/science-by-discipline/ecosystem-monitoring/kelp-forest-monitoring/subtidal-sampling-protoco.Generally, on each of the twelve $60m^2$ transects, densities of conspicuous (> 2.5cm dia) size classes of common invertebrates are recorded. Size frequencies of urchins and sea stars are recorded in the same categories described in the experiment. Densities of juvenile (> 1m height) and adults of the two canopy-forming (*Macrocystis* and *Nereocystis*) kelps, subcanopy-forming stipitate (> 30 cm height) kelps, and prostrate (> 10cm blade width) kelps and erect (> 6cm height) fucoids (e.g., *Cystoseira*) are recorded. Stratified subsampling is used to estimate densities of particularly abundant species such as urchins and snails. The distance along the transect in which the first 30 individuals are counted is recorded and this is repeated for each of three 10m subsections of the transect.

Uniform point contact is sampled (30 points at 1m intervals) to estimate percent cover of five morphological categories of foliose red algae, erect and encrusting coralline algae, and species of brown algae (e.g., Dictyotales). Percent cover of colonial or aggregating invertebrates are recorded at higher phyletic levels of taxonomic resolution (e.g., bryozoan, sponge, tunicate). Percent cover is also used to characterize the relative abundance of structural features of the rocky reef, including substratum type (sand, cobble, boulder, bedrock) and relief (0-10cm, 10cm-1m, 1m-2m, > 2m).

We will continue to follow urchin density and size-structure to track the progression of size classes, including recruitment and survivorship of the successful recruitment class seen in 2014. We will also record whether each individual urchin is exposed versus sheltered to estimate change in the proportion of exposed individuals. This will allow us to quantify the magnitude of the behavioral and possible demographic response to the decline of sea stars and how these correlate with spatial and temporal variation in combinations of relative densities of predators (otters, *Pisaster* and *Pycnopodia*).

We will test for temporal and spatial relationships between univariate (e.g., individual predator densities) and multivariate (e.g., relative abundances of predators) independent variables and univariate response variables (e.g., proportion of urchins exposed, urchin density, kelp density) and multivariate response variables (e.g., combinations of urchin and kelp densities). We will use ordinary least squares regression for these analyses, testing for spatial autocorrelation in residuals and, if significant, using geographically weighted regression analysis (*116*) to correct for bias.

6) Sea otter behavioral responses. To address the question of how sea otters have or have not responded to the sea star decline at larger scales, we will initiate a telemetry-based study of tagged otters, sampled randomly from within the study area, from which we will collect observational data on otter diets for comparison with equivalent data collected over the past 15 years in the same area (Figure 3; (*99*, *103*)).

Sea otter tagging, monitoring and data collection

We will capture and tag a sample of approximately 25 otters from the study area (north and west side of Monterey peninsula) following methods we have utilized for many previous studies in this area (*99*, *117*). All methods described below are covered under current Federal permits to T. Tinker and authorized by the UC Santa Cruz Institutional Animal Care and Use Committee (IACUC). Captures are conducted by a highly experienced and uniquely trained sea otter

capture team using closed-circuit SCUBA methods, underwater propulsion devices and specialized "wilson traps" (*118*). Captured animals are transported to the Monterey Bay Aquarium (MBA) for processing by an experienced veterinary team: animals are anaesthetized, tagged, and receive comprehensive health exams and bio-sampling. Anaesthetization follows well established protocols (*119*), and once unconscious each animal is equipped with color-coded flipper tags for visual identification and a surgically implanted VHF transmitter for radio telemetry tracking. Samples collected include blood (used for screening a standardized series of blood parameters, to evaluate health and contaminant/disease exposure), saliva and fur (for stress hormone analyses), and vibrissae which are used to evaluate long-term individual diets via stable isotope analysis (*120*, *121*). Participants in the capture/tagging phase include scuba divers and boat operators from UC Santa Cruz, USGS and California Department of Fish and Wildlife (CDFW), and veterinarians and staff from MBA.

After release, study animals are monitored regularly (using standardized VHF telemetry protocols: (*117*)) over the subsequent 3-year period corresponding to the transmitter battery life. Field personnel conduct shore-based daily surveys of the study site using standard telemetric protocols to locate all study animals (triangulation on radio signal using VHF telemetry receivers and visual identification using 50-80X Questar spotting scopes) and record precise GPS position, survival, reproductive status and instantaneous behavior. Attempts will be made to re-sight all study animals at least 5 times per week. Individual study animals are then selected haphazardly (subject to appropriate behavior and visual conditions) for collection of observational data on diet and feeding behavior, following well-established protocols (*99*, *102*, *122*, *123*). Briefly, the otter is observed using 50-80X spotting scopes (Questar Inc., Isanti, MN) over a contiguous sequence of 20 - 60 dives, referred to as a foraging bout. Information recorded includes date and time, precise location of each dive (determined by visual triangulation using GPS, compass and laser range-finder), duration of the subsurface dive interval (" DT") and the post-dive surface interval ("ST") for each feeding dive (in seconds), outcome of each dive (i.e. whether or not prey was captured), species of prey captured, number and size of prey items, per-item handling time (number of seconds required to handle and consume each item), whether or not tools were used to handle the prey, and ambient conditions (including sea-state, wind, etc.). Prey size is recorded as the estimated diameter of the shell or maximum body dimension (excluding appendages), categorized into 2.5 cm size-classes. For observations where prey cannot be reliably identified to species, the items in question are assigned to the lowest possible taxonomic unit. Any items that cannot be reliably categorized to any taxonomic level are listed as "unidentified". Additional information recorded by observers includes numbers of prey items that were stolen by or from the focal animal and, in the case of females with dependent pups, the number of items that were shared with the pups. Data are then analyzed to estimate prey-specific consumption rates, using a resampling procedure that uses Monte Carlo simulations to account for missing data parameters and adjust for sampling bias (see Tinker et al 2012, 2015).

We will attempt to collect 500-1000 dives per study animal over a 3 year period, augmented by an additional 5000 dives from randomly selected untagged otters in the same area, for a total sample size of ~15,000 recorded feeding dives. We will estimate the per-capita rate of predation on urchins and marine snails, and compare these with estimates available for 1999-2014 (for which we have an existing data set of over 60,000 recorded dives). We will used mixed-effects linear models (with individual otter treated as a random effect) to test for temporal trends in prey consumption rates.

7) Co-variation of predators and prey. To address this question, we will combine spatially-explicit data on prey consumption by otters (see above; Figure 3) with site-specific data on urchin and snail abundance from subtidal surveys. We will test for a relationship between prey abundance and otter consumption rates using ordinary least squares regression analysis. We

will test for spatial autocorrelation in residuals and, if significant, use geographically weighted regression analysis (*116*) to correct for bias.

8) Effect of Individual Specialization. Based on previously published analyses of otter diets around Monterey peninsula, we know that individual otters tend to specialize on a small suite of prey, such that the high diet diversity occurring at the population level is actually an emergent phenomenon reflecting the diversification of specialized diets among individuals (*99*, *102*, *103*, *120*, *121*). We might therefore expect that those otters specializing on a diet high in urchins or snails would show the earliest and most significant response to the increase in urchins and snails resulting from the local extinction of sea stars. This hypothesis implies an enhanced degree of individual specialization. An alternative hypothesis is that all otters will respond similarly to the "windfall" created by the sudden glut of urchins, a pattern that would imply a relaxation of individual specialization as all individual diets became more similar. To test these predictions, we will compare the degree of individual specialization in our current sample of tagged otters to that observed over the period 1999-2014. We will use diet similarity indices (*124*) to compare diets among individuals and to quantify the level of specialization for each study group.

Intellectual Merit

This project will advance our understanding of the combined roles of species diversity and predators in contributing to the stability and resilience of community structure. Though both of these elements of community structure have been the focus of numerous studies, fewer have explored how predator diversity does or does not enhance the resilience of marine ecosystems in field experiments. Specifically, elucidation of both the relative importance of direct (mortality) and indirect (prey behavior) trait-mediated effects of predators on prey density and foraging behavior, while simultaneously identifying the mechanisms (i.e. redundancy, complementarity) by which predator diversity determines the strength of this effect is critical to advancing our understanding of the roles of diversity and predation for ecosystem resilience. Dissecting these complex species interactions with unprecedented controlled field experiments to assess their causal relationships at scales relevant to real patch dynamics, combined with field surveys to evaluate their manifestation at scales of the whole ecosystem (kelp forests) collectively constitute the transformative potential of this research. Kelp forest ecosystems throughout temperate oceans in both southern (South America, New Zealand, Tasmania, southern Australia) and northern (New England) hemispheres, especially along the West Coast of North America (Mexico to Alaska), have had profound influence on our understanding of how abiotic (e.g., storm disturbance) and biotic (especially the role of predators) processes determine ecosystem stability and resiliency. By exploring these species interactions in kelp forest ecosystems, we capitalize on an extraordinary foundation of ecological understanding, hence the rationale for our focus on this system. In addition, the results of this study will inform our understanding of the ecological consequences and reasons for the extent and duration of ecosystem-wide impacts of the current sea star wasting event.

Broader Impacts

The broader impacts of this study include: graduate and undergraduate training, public outreach, and informing conservation managers and policy makers. Graduate training will be achieved through co-mentoring of one graduate student funded by this award by the two PIs. The graduate student will be involved in field studies, develop a species interaction model to explore the hypothesized interactions, and participate directly in outreach efforts. Marine Biology is one of the largest majors at UC Santa Cruz, with 260 current undergraduates. The program serves a substantial proportion of underrepresented students, including many Latino students who are the first in their family to pursue a college education. Undergraduate students pulled from this rich pool, will assist graduate students, faculty and researchers in all aspects of the study.

Our outreach efforts will have three main audiences: K-12 students, the general public, and marine resource managers. These efforts will be designed to provide information about the ecosystem consequences of sea star declines and the role of predator diversity in contributing to the resiliency of kelp forest ecosystems. Our outreach efforts will target four unique opportunities: the Monterey Bay Aquarium, the Seymour Discover Center on the UCSC Coastal Science Campus, UCSC's Broader Impacts Office, and a popular interactive website on sea star wasting information.

Based on the close involvement in this project of sea otter observers trained by the Monterey Bay Aquarium (MBAq), the Aquarium's Conservation program will facilitate disseminating information about the study and its results through their extensive outreach program, including a huge K-12 educational program (see letter of commitment and support submitted by MBAq.

UCSC is strongly committed to Broader Impacts (BI) and has developed a BI Office to facilitate researchers achieving the broader impacts of their research (http://officeofresearch.ucsc.edu /broader-impacts/). Among the many outreach avenues identified by the BI Office, the Seymour Marine Discovery Center (http://seymourcenter.ucsc.edu/) located on UCSC's Coastal Science Campus provides a conduit to K-12 programs and general public who visit the Center. We will co-develop a video presentation with the Center's display team through this grant and a collaboration with the Science Communication program at UC Santa Cruz (http://scicom.ucsc.edu). This video will build upon existing work at the Seymour Center to develop a video display, funded by earlier NSF support (see letter of commitment and support from the Center's Director).

Associated investigator Raimondi maintains a website and interactive map for tracking the incidence of sea star wasting (http://www.eeb.ucsc.edu/pacificrockyintertidal/dataproducts/ sea-star-wasting/), which we will continue to inform throughout the project. This website provides information to the interested public as well as a nexus for information exchange between scientific colleagues.

Management and policy institutions whose decisions and actions will benefit from the findings of this project include California's Department of Fish and Wildlife (CDFW) and Ocean Science Trust, which houses the state's Monitoring Enterprise. Both agencies are tasked with monitoring and managing marine protected areas (MPAs). Both institutions will benefit from knowledge of the ecological mechanisms that may underpin the geographic variation, including inside and outside of MPAs, in the dynamics of the wasting event, including the ecosystem-wide consequences of reduced sea star densities, and the mechanisms of resiliency of kelp forests. The PIs are well situated to ensure that this study informs MPA managers in California. PI Carr and associated investigator Raimondi both work closely with California's Monitoring Enterprise (http://monitoringenterprise.org/where/california.php) and the CDFW on the monitoring, assessment and applications of MPAs (see Synergistic Activities sections of their CVs). Federal agencies that will benefit from knowledge generated by the study include The Monterey Bay National Marine Sanctuary (MBNMS), tasked with evaluating and protecting the status of the Sanctuary's ecosystems, and the USGS Western Ecological Research Center, responsible for understanding both the ecological significance of the otter and processes that influence its recovery (e.g., kelp forest resiliency). Involvement of associated investigator Lonhart (MBNMS) and Co-PI Tinker (USGS) will ensure that MBNMS and USGS are well informed of the results of this study.

Results from prior NSF support:
(a) NSF award number: OCE-1041454, **amount:** $465,078, **period of support:** 07/15/2010 - 06/30/2014, Mark H Carr, Principal Investigator; James A Estes, Co-Principal Investigator. Dr. Jennifer Caselle was Principal Investigator on the **collaborative award number:** OCE-10411489**.**
(b) title: CAMEO: Comparative Approaches to Predicting the Consequences of an Impending Re-Invasion: Top Predator Effects on Californian Near-Shore Fisheries

Relevant Sea Otter Publications resulting from prior versions of MA672624

Fujii, J.A., Ralls K, **Tinker M.T**. (2017) Food abundance, prey morphology, and diet specialization influence individual sea otter tool-use. Behavioral Ecology, 28(5), 1206-1216. doi:https://doi.10.1093/beheco/arx011

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Estes, J.A. J. Terborgh, J. S. Brashares, M.E. Power, J. Berger, W. J. Bond, S. R. Carpenter, T. Essington, R. D. Holt, J. B.C. Jackson, R. J. Marquis, L. Oksanen, T. Oksanen, R. T. Paine, E. K. Pikitch, W. J. Ripple, S. A. Sandin, M. Scheffer, T. W. Schoener, J. B. Shurin, A. R.E. Sinclair, M. E. Soulé, R. Virtanen, and D. A. Wardle. 2011. Trophic downgrading of planet earth. Science 333:301-306

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Conrad, P. A., E. VanWormer, K. Shapiro, M. Miller, C. Kreuder-Johnson, **T. Tinker**, M. Grigg, J. Largier, T. Carpenter, and J. K. Mazet. 2009. Tracking toxoplasma gondii from land to sea. American Journal of Tropical Medicine and Hygiene 81:198-198.

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Miles, A.K., M.A. Ricca, R.G. Anthony, and **J.A. Estes**. 2009. Organochlorine contaminants in fishes from coastal waters west of Amukta Pass, Aleutian Islands, Alaska, USA. Environmental Toxicology and Chemistry 28:1643-1654.

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Tinker, M.T., **Bentall, G.B.**, and **J.A. Estes**. 2008. Food limitation leads to behavioral diversification and dietary specialization in sea otters. Proceedings of the National Academy of Sciences 105(2):560-565.

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Curriculum vitae

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EDUCATION

Doctor of Veterinary Medicine, University of California- Davis Davis CA. June 2005
Ph.D, Comparative Pathology, University of California- Davis, Davis CA. June 2005
Dissertation Title: A biophysical characterization of Northern Elephant Seal (*Mirounga angustirostris*) blood platelets and their response to temperature and pressure changes.
B.S. Physiology, Spanish minor, University of California- Davis, Davis CA. June 1993

PROFESSIONAL EXPERIENCE

Staff Veterinarian, The Marine Mammal Center, Sausalito, CA. Oct 2014-**present**

- Veterinary care for stranded marine mammals including clinical medicine and surgery, emergency treatment, necropsy, records and supervise animal husbandry
- Supervise and train full-time veterinary intern, residents, and students in marine mammal medicine
- Outreach with general public, media regarding animal health and institution mission,
- Develop clinical techniques, studies and research projects, present clinical cases and research findings in professional scientific and public forums

Senior Associate Veterinarian, Georgia Aquarium, Atlanta, GA. Jan 2014-Sep 2014

- Clinical and preventative health care of marine mammal, fish, avian, reptile, amphibian and invertebrate collection, including medical and surgical procedures, advanced diagnostics, necropsy, more
- Directly oversee, instruct and mentor full-time veterinary residents and student extern program
- Outreach with general public, media regarding animal health, role of aquaria/zoological institutions
- Present clinical cases and research findings in professional scientific and public forums, including the following projects: beluga exhale sampling, efficacy of carprofen in cownose rays, penguin and elasmobranch protein/lipoprotein electrophoresis, propofol use in elasmobranchs, blood transfusions in elasmobranchs

Associate Veterinarian, Georgia Aquarium, Atlanta, GA. Jan 2012- Jan 2014

- Clinical and preventative health care of above collection above
- Instruction/mentorship of veterinary residents, veterinary intern/fellow and vet student extern program
- Outreach with students, general public, media regarding marine system and animal health
- Clinical research and case presentations at professional scientific and public forums

Associate Veterinarian, Audubon Nature Institute**.** New Orleans, LA. Aug 2009- Jan 2012

- Clinical and preventative health care for extensive aquarium, zoo and endangered Species Survival Center collections (medical/surgical procedures, reproductive laparoscopic techniques, necropsy, remote anesthetic delivery system use
- Continuous instruction/mentorship of veterinary residents, interns, vet student externs
- Veterinarian for Louisiana Marine Mammal and Sea Turtle Rescue Program including rescue, rehabilitation/veterinary care, release and tracking of stranded animals, necropsy, staff/intern training
- Onsite coordinator/manager/clinician for oiled sea turtles and dolphins during the BP Gulf Oil Spill 2010 and concurrent dolphin UME. Evidence collection/handling, chain of custody, HazMat training, supervision of rehabilitation efforts of large group of vets, students, interns, volunteers

Post-Doctoral Fellow, Mystic Aquarium/ Univ. of Connecticut**,** Mystic, CT. June 2008 - Aug 2009

- Conduct original cell biological research of marine mammal brucellosis and run diagnostic testing program
- Present research findings in public and professional forums including publications

- Mentor/instruct veterinary intern and students, and research program interns (undergrad, graduate)
- Veterinary care of large marine mammal and fish collection, and stranded marine mammals

Veterinary Intern in Aquatic Medicine, Mystic Aquarium, Mystic, CT. June 2007-June 2008
- Primary veterinary care for diverse marine mammal, fish, avian, reptile and invertebrate collection and stranded animals, including medical and surgical treatments, advanced diagnostics, remote anesthetic/medication delivery
- Design, conduct, present individual research project in cownose stingrays; marine Brucella research
- Instruct veterinary students, undergraduates and volunteers in medicine, research, stranding response
- Education/outreach with the general public

Post-Doctoral Researcher, Mystic Aquarium, Mystic, CT. Jul 2006- Jun 2007
- Serologic, molecular, microbiological and cell biological research for NOAA-OHHI marine Brucella grant
- Present scientific findings in public forums (conferences and publications)
- Assist veterinary staff with collection and stranded animal care and necropsies
- Collaborative human diving research project with US Navy

Contract Veterinarian, Luv My Pet Clinics CT/RI. Part time; August 2006- August 2009
- Small animal low cost vaccination clinic, microchip implantation, diagnostic testing

Staff Veterinarian, Humane Society of Sonoma County, Santa Rosa, CA. Jul 2005- Jun 2006.
- Shelter and private small/exotic animal medicine and management
- Public/community outreach including lectures in animal first aid and emergency response

Research Assistant in Cell Biology, Dept.of Anatomy, Physiology and Cell Biology. 1998- 2003 University of California- Davis, Davis, CA. Concurrent with Ph.D program

Post-graduate Researcher, Dept of Anatomy, Physiol, Cell Biology. UC Davis, Davis CA. 1995-1998
- Research in cellular biological techniques including characterization of platelet interactions for sickle cell anemia, characterization of mammalian species megakaryocytes, mammalian platelet membrane phase transition evaluation.

TEACHING EXPERIENCE

Instructor AQUAVET® 1; University of Pennsylvania/Cornell University, June 2009 - 2014. Marine mammal taxonomy, life history anatomy, physiology, medicine, research, necropsy

Instructor AQUAVET® 3; Georgia Aquarium, June-July, 2013 and 2014. Instruction of select group of veterinary students in aquatic animal anatomy, physiology and medicine, including marine mammals, teleosts, elasmobranchs, invertebrates, reptiles, amphibians, zoonosis and more

Instructor Oiled Wildlife Care Workshop. University of Georgia Athens, Feb 24, 2014

Instructor Advanced Fish Medicine; University of Florida/ Georgia Aquarium, March 2013.

Coordinator/Instructor Sea Turtle and Marine Mammal Workshop. New Orleans, LA; January 28, 2012. Effects of Oil on Wildlife Conference: created, organized and conducted workshop in sea turtle and marine mammal anatomy, physiology, habitat, distribution, and oil spill response.

Instructor/Coordinator Marine Mammal Biology Seminar course. U. Connecticut/ U. Rhode Island/ Mystic Aquarium; January 2009- May 2009; instructor 2008

Teaching Assistant: Biology, Dept.of Biological Sciences. University of California- Davis, Davis, CA. Sept-Dec, 1999

RELATED EXPERIENCE

Belize Manatee Tagging and Health Assessment: Belize, May 27-June 8, 2013, with USGS/ Sea to Shore/ Oceanic Society. Veterinary support during wild manatee tagging, health assessment and population investigation

UME Co-Investigator: Feb 2010 to present: Ongoing Gulf of Mexico dolphin Unusual Mortality Event

Dolphin Health Assessment: Aug 3-17, 2011. NOAA/NMFS evaluation of local wild bottlenose dolphin health post Deepwater Horizon oil spill in Barataria Bay, Grand Isle, LA.

Chemical Immobilization of Animals, Feb 2010, Baton Rouge, LA. Safe Capture International Inc. 16 hour workshop in safe immobilization of mixed animal species

Florida Manatee Health Assessment: December, 2009. Crystal River, Florida. Wild manatee captures for health evaluation and research, with USGS and University of Florida

Beluga Whale Field Research: Jun-Jul 2009, Point Lay, Alaska. Wild beluga sample collection

The Marine Mammal Center Veterinary Externships: Apr-May 2005. Sausalito, CA. Stranded marine mammal care including rescue and rehabilitation, medicine, surgery, anesthesia, necropsy
Oiled Wildlife Care Network Veterinary Externship, Feb 2005. University of California, Davis. Rescue, care and release of oiled wildlife, particularly avian species
Mote Marine Laboratory Veterinary Externship, Aug 2004. Sarasota, FL. Rehabilitation of stranded sea turtles and cetaceans, collection animal care, local wildlife rehabilitation at neighboring avian/wildlife rehab center (Pelican Mans)
Bodega Bay Marine Biology research program, Bodega Bay Marine Laboratory, UC Davis, Apr-Jun 1993. Intensive instruction in marine ecology, biology, and physiology, conduct/present original research project
Cetacean Field Research, San Francisco State University, San Francisco, CA June 1990. Wildlands Studies Program including population and behavior assessment of St. Lawrence Estuary cetaceans using boat transects, tracking and photo identification techniques

AWARDS/ HONORS

Post-doctoral fellowship recipient: NOAA-OHHI Interdisciplinary Research and Training Initiative Coastal Ecosystems Human Health (I-RICH). June 2008-June 2009
Student Travel Award for IAAAM annual conference, May 2009
Recipient "Best presentation" award, IAAAM annual conference, May 2008.
Student Travel award for IAAAM annual conference, May 2008
Student Travel award for IAAAM annual conference, May 2007
Recipient: VSTP (dual DVM/PhD) Scholarship, School of Vet Medicine, University of California,Davis, 2001-2005

COMMUNITY SERVICE

Rhode Island State Science Fair Judge, Community College of Rhode Island 2008, 2009
Sonoma County Wildlife Rescue, Volunteer Veterinarian, Santa Rosa, CA. Jul 2005-Jun 2006. Care of injured and diseased wildlife, outreach and education of local rehabilitators and general public
Rural Area Veterinary Service (RAVS) volunteer. Palau, Micronesia June-July, 2005; Rosebud, SD, March 2003; Covelo, CA, November 2003 and February 2004. Free spay, neuter, vaccination and general medicine clinics in low income regions (national and international trips), as well as outreach and education of animal health
The Marine Mammal Center Animal Care Crew Volunteer, Sausalito, CA. July 1998- June 2005. Care and rehabilitation of injured/diseased marine mammals and sea turtles, stranded animal response, rescue and necropsy, education and outreach with general public (Sunday Day Crew)
Mercer Clinic volunteer, Sacramento, CA. 2001-2003. Free veterinary clinic for homeless pets

SCHOLARLY SERVICE: Reviewer for the following journals: Marine Mammal Science, Aquatic Mammals, Research in Veterinary Science, Journal of Wildlife Diseases, Veterinary Record, Journal of Zoo and Wildlife Medicine, Zoo Biology
MEMBERSHIPS: International Association for Aquatic Animal Medicine (IAAAM); Society for Marine Mammology (SMM); American Association of Zoo Veterinarians (AAZV); American Veterinary Medical Association (AVMA)

PUBLICATIONS

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Meegan J, **Field C**, Sidor I, Romano T, Casinghino S, Smith CR, Kashinsky L, Fair PA, Bossart G, Wells R, Dunn JL. (2010) Development, validation and utilization of a competitive enzyme-linked immunosorbent assay for the detection of antibodies against Brucella species in marine mammals. J Vet Diagn Invest 22(6):856-62

Ferreira CM, **Field, CL**, Tuttle, AD. (2010) Hematological and plasma biochemical parameters of aquarium-maintained cownose rays. Journal of Aquatic Animal Health 22:123-128, 2010

Goldstein T, Stephens CA, Jang SS, Conrad PA**, Field C**, Dunn JL, Mellish JE. (2007) Longitudinal Health and Disease Monitoring in Juvenile Steller Sea Lions (*Eumetopias jubatus*) in Temporary Captivity in Alaska Compared with a Free-Ranging Cohort. Aquatic Mammals 33:337-348

Gousset K, Wolkers WF, Tsvetkova NM, Oliver AE, **Field CL**, Walker NJ, Crowe JH, and Tablin F. (2002) Evidence for a physiological role for membrane rafts in human platelets. J Cell Physiol 190: 117-128

Field CL, Walker NJ, Tablin F. (2001) Northern Elephant seal platelets: Analysis of shape change and response to platelet agonists. Thromb Res 101: 267-277

Tsvetkova NM, Walker NJ, Crowe JH, **Field CL**, Tablin F. (2000) Lipid phase separation correlates with activation in platelets during chilling. Molec Memb Biol 17: 209-218

Tablin F, Walker NJ, **Field CL**, Crowe JH. (2000) Animal models for studies on cold-induced platelet activation in human beings. J Lab Clin Med 135: 339-346

Wun T, Paglieroni T, **Field CL**, Welborn J, Cheung A, Walker NJ, Tablin F. (1999) Platelet-erythrocyte adhesion in sickle cell disease. J Invest Med 47(3): 121-127

Tablin F, Rabier MJ, Walker NJ, Velasco VM, **Field CL**, Leven RM. (1998) Tenascin-C is synthesized and secreted by megakaryocytes, whose adherence to intact tenascin is mediated by the integrin 8:142-149

Wun T, Paglieroni T, Cordoba M, Welborn J, Rangaswami A, **Field C**, Cheung A, Tablin F. (1997) Intracellular tumor necrosis factor--with sickle cell disease. Blood 90, suppl 1(2):2835

PRESENTATIONS

39th Annual Eastern Fish Health Workshop, April 2014. Title: The EPO Depot: Anemia and blood transfusions elasmobranchs

IAAAM 44th Annual Conference, April, 2013. Title: Effects of propofol anesthesia on bonnethead (Sphyrna tiburo) and sandtiger (Carcharias Taurus) shark cardiorespiratory and blood gas parameters.

Effects of Oil on Wildlife Conference, January, 2012. Title: Intake and treatment of oiled sea turtles in Louisiana during the 2010 BP Deepwater Horizon oil spill.

IAAAM 42nd Annual Conference, May 2011. Title: Intake and treatment of oiled sea turtles in Louisiana during the 2010 BP Deepwater Horizon oil spill.

2nd Annual Wisconsin Exotic and Zoo Animal Medicine Club Symposium invited speaker: Nov. 2009. Title: Marine Brucella Diagnostics and Emerging Diseases.

IAAAM 40th Annual Conference, May 2009. Title: Intracellular Cytopathic Effects of Marine Brucella on Human and Beluga Monocytes.

34th Annual Eastern Fish Health Workshop, April 2009. Title: Effects of Carprofen on Cyclooxygenase Production by Blood Cells from the Cownose Ray.

37th Annual European Association for Aquatic Mammals Conference, March 2009. Title: Medical and Surgical Management of a Harp Seal with Pneumonia and Foreign Body Ingestion.

IAAAM 39th Annual Conference, May 2008. Title: Disseminated fungal infection in a California Sea Lion with detection of cystofilobasidiomycete DNA.

NOAA-OHHI Annual Primary Investigator Symposium, Michigan, Oct. 2007. Title: The impact of marine-origin Brucella on marine mammal and human health.

IAAAM 38th Annual Conference, May 2007. Presentation title: A Comparison of Marine-origin Brucella seroprevalence between 3 populations of sea otters.

Society for Marine Mammology 16th Biennial Meeting, December, 2005. Presentation title: Rapid decompression does not induce activation of Northern Elephant Seal platelets: A comparative study with human platelets

IAAAM 35th Annual Conference, April 2004. Presentation title: High Hydrostatic pressure significantly inhibits the rise in Northern Elephant Seal platelet calcium: A comparative study with human platelets.

IAAAM 34th Annual Conference, May 2003. Presentation title: Rapid decompression induces microvesiculation but not activation in Northern Elephant Seal platelets.

IAAAM 33rd Annual Conference, May 2002. Presentation title: Northern Elephant Seal Platelets are protected from platelet activation associated with rapid decompression.

Society for Marine Mammology 13th Biennial Meeting, November 1999. Presentation title: Ultrastructure and function of Northern Elephant Seal platelets.

Curriculum Vitae
JACK AMES
California Department of Fish and Wildlife, Office of Spill Prevention and Response
Marine Wildlife Veterinary Care and Research Center
151 McAllister Way, Santa Cruz, CA 95060
[redacted] (cell); 831.469.1723 (fax)
jack.ames@wildlife.ca.gov

EDUCATION

Bachelor of Science, Sacramento State College, June 1967

EMPLOYMENT HISTORY

July 1967-June 1972 CA Department of Fish and Game Fisheries Biologist

Duties: monitoring albacore tuna fishery and assessing sportfish populations on manmade habitats

July 1972-Sept 2011 CA Department of Fish and Game Sea Otter Biologist

Duties: participation in the design and construction of equipment used in three methods of sea otter capture, participation in the collection of dead sea otter carcasses, participation in sea otter necropsies, participation in twice annual sea otter counts, participation in studies to understand the accuracy of sea otter counts, participation in studies designed to understand the effect of various kinds of fishing gear on sea otter mortality, participation in the design, and construction and stockpiling of portable, floating, holding pens for potential use with oil-injured sea otters

October 2011-present CA Department of Fish and Wildlife Retired Annuitant
(Formerly CA Department of Fish and Game)

Duties: assist with various sea otter research and conservation projects at the Marine Wildlife Veterinary Care and Research Center and various projects with collaborators

SELECT PUBLICATIONS

Wild, P.W., and **Ames, J.A.** (1974). A report on the sea otter, *Enhydra lutris L.*, in California. Marine Resources Technical Report No. 20, CDFG, 95pp.

Morejohn, G. V., **Ames, J. A.**, & Lewis, D. B. (1975). Post mortem studies of sea otters, *Enhydra lutris L.*, in California. Marine Resources Technical Report No. 30, CDFG, 87pp.

McCleneghan, K., & **Ames, J. A.** (1976). A unique method of prey capture by a sea otter, *Enhydra lutris*. *Journal of Mammalogy*, *57*(2), 410-412.

Ames, J. A., & Morejohn, G. V. (1980). Evidence of white shark, Carcharodon carcharias, attacks on sea otters, *Enhydra lutris*. *California Fish and Game*, *66*(4), 196-209.

Williams, T. D., Mattison, J. A., & **Ames, J. A.** (1980). Twinning in a California sea otter. *Journal of Mammalogy*, *61*(3), 575-576.

Ames, J. A., Hardy, R. A., & Wendell, F. E. (1986). A simulated translocation of sea otters, *Enhydra lutris*, with a review of capture, transport and holding techniques. Marine Resources Technical Report No. 52, CDFG, 17pp.

Faurot, E. R., **Ames, J. A.**, & Costa, D. P. (1986). Analysis of sea otter, *Enhydra lutris*, scats collected from a California haulout site. *Marine Mammal Science*, *2*(3), 223-227.

Wendell, F. E., Hardy, R. A., & **Ames, J. A.** (1986). An assessment of the accidental take of sea otters, *Enhydra lutris*, in gill and trammel nets. Marine Resources Technical Report No. 54, CDFG, 31pp.

Garshelis, D. L., **Ames, J. A.**, Hardy, R. A., & Wendell, F. E. (1990). Indices used to assess status of Sea Otter populations: a comment. *The Journal of wildlife management*, 260-269.

Bodkin, J. L., **Ames, J. A.**, Jameson, R. J., Johnson, A. M., & Matson, G. M. (1997). Estimating age of sea otters with cementum layers in the first premolar. *The Journal of wildlife management*, 967-973.

Estes, J., Hatfield, B. B., Ralls, K., & **Ames, J.** (2003). Causes of mortality in California sea otters during periods of population growth and decline. *Marine Mammal Science*, *19*(1), 198-216.

Jessup, D. A., Miller, M., **Ames, J.**, Harris, M., Kreuder, C., Conrad, P. A., & Mazet, J. A. (2004). Southern sea otter as a sentinel of marine ecosystem health. *EcoHealth*, 1(3), 239-245.

Miller, M. A., Byrne, B. A., Jang, S. S., Dodd, E. M., Dorfmeier, E., Harris, M. D., **Ames, J.A**.,... & Miller, W. A. (2010). Enteric bacterial pathogen detection in southern sea otters (*Enhydra lutris nereis*) is associated with coastal urbanization and freshwater runoff. *Veterinary research*, *41*(1), 1-13.

Young, C., Eguchi, T., **Ames, J.A**., Staedler, M., Hatfield, B. B., Harris, M., & Golson-Fisch, E.A. (2019). Drift and beaching patterns of sea otter carcasses and car tire dummies. *Marine Mammal Science* early access: DOI: 10.1111/mms.12609

Curriculum Vitae

NANCY L. ANDERSON, DVM, ABVP (Avian), PhD

Employment History

Dates	Institution	Position
2011-present	Oiled Wildlife Care Network	Field Veterinarian
2010-2011	Six Flags Discovery Kingdom	Staff Veterinarian
2000-2010	Lindsay Wildlife Museum	Director of Wildlife Services 2006-2009, Deputy Director
1997-2002	The Ohio State University	Graduate Research Associate Dept. Evolution, Ecology and Organismal Biology
1992-2000	The Ohio State University	Director Raptor Rehabilitation Program
1991-1997	The Ohio State University	Assistant Professor, Clinical 1992-1996, Director General Practice
1990-1991	Marysville Animal Care Center	Associate Veterinarian
1989	Harcourt Veterinary Clinic	Associate Veterinarian
1988	Relief Veterinarian	Veterinarian

Education

Date	Institution	Degree
2002	The Ohio State University	PhD: Ecophysiology
1994	American Board of Veterinary Practitioners	Avian Medicine Specialty
1989	The Ohio State University *cum laude* with University Honors	BS: Agricultural Engineering
1988	The Ohio State University *cum laude*	DVM

Professional Licenses

DEA: Controlled Substances Administration Certificate
California Veterinary Medical Board
Ohio Veterinary Medical Board
USDA Accredited

Educational Awards

Raymond C. Osburn Memorial Graduate Fellowship
Phi Zeta Veterinary Honor Society
Alpha Epsilon Agricultural Honor Society

Tau Beta Pi Engineering Honorary
Women in Engineering Award
Ford Motor Company Women in Engineering Award
Caterpillar Tractor Company Women in Engineering Award
Chimes Junior Honor Society
Romophos Sophomore Honor Society
Freshman Scholar, The Ohio State University
Alpha Lambda Delta, Freshman Honor Society
Phi Eta Sigma, Freshman Honor Society
National Council of Teachers of English Achievement Award in Writing

General Fields of Interest

Working with colleagues to develop innovative and effective solutions to challenges encountered when working with wildlife, exotic animals and domestic species. My interests range from individual animals to a population level.

Develop and implement presentations and materials that provide staff, students, and the general public with the information/training necessary to understand fundamental concepts pertinent to the task/topic at hand and to perform their work with thoughtful attention and enthusiasm.

Backpacking, canoeing, bird watching, SCUBA diving, ballroom dancing

Teaching Experience

Department of Medicine and Epidemiology: University of California, Davis

Zoological Avian Medicine, Avian Physiology, Avian Neurology, Field Techniques for Assessment of Wildlife and Ecosystems, Reptile Handling Laboratory, Reptile Nutrition, Health & Disease in Terrestrial Wildlife

Department of Evolution, Ecology, and Organismal Biology: The Ohio State University

Dynamics of the Dinosaurs, Vertebrate Dissection Laboratory, Evolution, Introduction to Ecology Laboratory and Lecture

Department of Veterinary Clinical Sciences: The Ohio State University

Senior General Practice Clinical Rotation, Non-mammalian Core Curriculum, Avian Medicine, Advanced Avian Medicine, Reptile Medicine, Small Mammal Medicine, Veterinary Population Medicine, Raptor Medicine, Animal Behavior

Service Work

2018	Reviewer Marine Ornithology
2016	Proceedings Reviewer for Arctic Marine Oil Pollution Conference
2012 to present	Manage and advisor for the Phil and Karen Drayer Wildlife Health Center Fellowship Award.
2014 to present	Teach avian skills wetlab for UC Davis veterinary students: Wildlife and Aquatic Medicine Club

2013-2014	Member Disaster Preparedness Committee for the American Association of Zoo Veterinarians
2011	Author Sea Turtle Fibropapilloma article for Infectious Disease Committee for American Association of Zoo Veterinarians
2006– 2010	Department of Fish and Game Task Force to investigate emerging diseases in great grey owls in the Yosemite region.
2004 – 2010	Member Scientific Advisory Board: Oiled Wildlife Care Network
2001 – 2010	Mentor Lindsay Wildlife Museum veterinary student externships
2007-2009	Associate Editor for Journal of Zoo and Wildlife Medicine
2007	Member American Association of Wildlife Veterinarians Ad Hoc Policy Committee on Communications Strategies
2005-2006	Co-author rodent and small mammal section for Guidelines for Euthanasia of Nondomestic Animals published by the Association of Zoo Veterinarians
2000 – 2001	Associate Editor, Reptile Section of Petplace.com
1998 – 2002	Associate Editor, Medicine Section for the Journal of Reptile and Amphibian Medicine and Surgery
1998 – 1999	Seminar Speaker Chair for Evolution and Ecology Grad Students
1998 – 1999	Local host for ARAV/AAZV Annual Meeting
1997 – 2000	Volunteer mentor for OSU Raptor Rehabilitation Program
1996 - 1997	Co-chair 21st OSU/Waltham Symp on Exotic Animal Medicine
1996 - 1999	American Board of Veterinary Practitioners Avian Core Examination Committee
1996 - 1999	Consulting Co-editor Current Veterinary Therapy XIII Diseases of Birds and Exotic Pets Section
1996	Reviewer <u>Manual of Raptors, Pigeons, and Waterfowl</u>, Iowa State University Press
1996	Reviewer <u>Client Information Series</u>, Veterinary Practice Publishing Company
1995	Reviewer for <u>Biology of the Reptilia</u>, Academic Press
1993 – 1994	OSU: Non-mammalian species core course planning committee
1991 - present	Association of Avian Veterinarians Student Chapter Committee (1991 - 1997) University Curriculum Committee (1991 - 1997)
1991 – 1997	OSU: Advisor Student Chapter AAZV/AAV
1991 – 1997	OSU: Advisor to students on Academic Probation

Professional/Academic Association Memberships

1988 - present	American Veterinary Medicine Association
1988 - present	Association of Avian Veterinarians
1994 - present	American Board of Veterinary Practitioners
2000 – present	American Association of Zoo Veterinarians
2000 – present	California Veterinary Medical Association
2004 – present	Wildlife Disease Association

2000 - 2012	American Association of Wildlife Veterinarians
2000 - 2012	International Wildlife Rehabilitations Council
1991 - 2012	National Wildlife Rehabilitators Association

Pertinent Recent Veterinary Continuing Education

2017	American Association of Zoo Veterinarians Annual Meeting
2016	National Animal Health & Stranding network Conference
2016	Project Management Course
2016	Teaching and Learning in the Clinical Setting
2016	Atlantic Coast Veterinary Conference
2010-15, 2004 –08	American Association of Zoo Veterinarians Annual Meeting
2011	Shark Reef Aquatic Animal Medicine Seminar
2011	USDA workshop: Tuberculosis in elephants
2010, 2007, 2005	Association of Avian Veterinarians Annual Meeting
2009 - 2016	24 hour HAZWOPER (refresher)
2005, 2006, 2009	Annual UC Davis WAAM Wildlife Medicine Symposium
2005	CDFG Advanced Chemical Immobilization Course
2004, 2005	California Council for Wildlife Rehabilitators Annual Symposium
2004	CDFG HAZCOM Course: 1001
1999	GIS and Remote Sensing for Wildlife Managers, Smithsonian Institution

Publications

Refereed Journals

2011. Siembieda JL, Miller WA, Byrne BA, Ziccardi MH, Anderson N, Chouicha N, Sandrock CE, Johnson CK. Zoonotic pathogens isolated from wild animals and environmental samples at two California wildlife hospitals. J Am Vet Med Assoc. 238(6): 773-83.

2010. Anderson NL, Johnson CK, Fender S, Heckly S, Metzler M, Nave P, Yim J. Clinical signs and histopathologic findings associated with a newly recognized protozoal disease (Trichomonas gallinae) in free-ranging house finches (Carpodacus mexicanus). J Zoo Wild Med. 41(2): 249-254.

2010, Ley DH, Anderson N. Dhondt KV, Dhondt AA. Mycoplasma sturni from a California House Finch with conjunctivitis did not cause disease in experimentally infected House Finches. J Wildl Dis. 46(3): 994-9.

2009. Anderson NL, Grahn RA, Van Hoosear KA, BonDurant RH. Studies of trichomonad protozoa in free ranging songbirds: Prevalence of Trichomonas gallinae in house finches (Carpodacus mexicanus) and corvids and a novel trichomonad in mockingbirds (Mimus polyglottos). Vet Parasitol 161: 178-186.

2009. Anderson NL. Late Stage Granulomatous Interstitial Pneumonia Secondary to Near-drowning in an Osprey (Pandion haliaetus). J Wildl Rehab: 29: 10-21.

2008. Hetherington TE, Coupe B, Perry G, Anderson N, Williams JB. Diurnal refuge-site selection by Brown Treesnakes (Boiga irregularis) on Guam. Amphib Rept: 29(2): 284-287.

2008. Ishak HD, Dumbacher JP, Anderson NL, Keane JJ, Valkiunas G, Haig SM, Tell LA, Sehgal NM. Blood parasites in owls with conservation implications for the spotted owl (Strix occidentalis). PLoS ONE 3(5): e2304. doi:10.1371/journal.pone.0002304.

2007. Anderson NL. Sporotrichosis in a broad-footed mole (Scapanus latimanus), a zoonotic disease. J Wildl Rehab 28: 18-21.

2007. Padgett KA, Reisen WK, Kahl-Purcell N, Fang Y, Cahoon-Young B, Carney R, Anderson N, Zucca L, Woods L, Husted S, Kramer V. West Nile infection in tree squirrels (Rodentia: Sciuridae) in California, 2004-2005. Am J Trop Med Hyg: 76: 810-813.

2006. Anderson NL. Clostridial enteritis in a mallard duck (Anas platyrhynchos). J Wildl Rehab 28: 4-12.

2006. Sehgal RNM, Hull AC, Anderson NL, Valkiunas G, Markovets MJ, Kawamura S, Tell L. Evidence for cryptic speciation of Leucocytozoon spp. (Haemosporida, Leucocytozoidae) in diurnal raptors. J Parasitol 92: 375-379.

2005. Anderson NL, Hetherington TE, Coupe B, Perry G, Williams J, Lehman J. Thermoregulation in a nocturnal, tropical, arboreal snake. J Herp 39: 82-90.

2004. Wack RF, Anderson NL. Resuscitation of a Hispaniolan slider (Trachemys decorata) using Oxyglobin and a blood transfusion. J Herp Med Surg 14: 4-5.

2003. Anderson NL, Hetherington TE, Williams JB. Validation of the doubly labeled water method under low and high humidity to estimate metabolic rate and water flux in a tropical snake (Boiga irregularis). J Appl Physiol 95: 184-191.

2000. Anderson NL, Coupe B, Perry G, Hetherington TE, Williams JB. Field use of propofol: a rapid recovery anesthetic with data from brown treesnakes (Boiga irregularis). Herp Rev 30: 161-163.

1999. Anderson NL, Wack RF, Calloway L, Hetherington TE, Williams JB. Cardiopulmonary effects and efficacy of propofol as an anesthetic agent in brown treesnakes, Boiga irregularis. Bull Assoc Rept Amphib Vet 9(2): 9-15.

1997. Anderson NL, Wack RF, Hatcher R. Hematology and clinical chemistry reference ranges for clinically normal, captive New Guinea snapping turtle (Elseya novaeguineae) and the effects of temperature, sex, and sample type. J Zoo Wildl Med 28(4): 394-403.

1997. Anderson NL. Recurrent deep foreign body granuloma in the tongue of an African Grey Parrot (Psittacus erithacus timneh). J Avian Med Surgery 11(2): pp. 105-109.

1997. Anderson NL. Editorial: The need to teach exotic animal medicine in veterinary schools. J Avian Med Surgery 11(2): p. 75.

1996. Anderson NL, Williams J, Sagartz J, Barnewell, R. Ovarian teratoma in Iguana iguana. J Zoo Wildl Med 27(1): 90-95.

1994. Wack RF, Kramer LW, Anderson NL. Cardiomegaly and endocardial fibrosis in a secretary bird (Sagittarius serpentarius). JAAV 8(2): 76-80.

1993. Anderson NL. Candida/megabacteria proventriculitis in a Lesser Sulfur Crested Cockatoo (Cacatua sulphurea sulphurea). JAAV 7(4):197-201.

1992. Anderson NL. Diseases of Iguana iguana.: Compend Contin Educ Prac Vet 14(10): 1335-1343.

1991. Anderson NL. Husbandry and clinical evaluation of Iguana iguana.: Compend Contin Educ Prac Vet 13(8): 1265-1272.

Book Chapters/Proceedings/Posters (not listed under presentations)

2006. McClure D, Anderson NL. Rodents and small mammals. In: Guidelines for Euthanasia of Nondomestic Animals. Association of Zoo Veterinarians Pp. 61-65.
2006. Anderson NL. Pet rodents. In Birchard SJ, Sherding RG eds.: Saunders Manual of Small Animal Practice 3rd ed. Philadelphia: W.B. Saunders, pp. 1881-1909.
2006. Anderson NL, Wack RF. Basic husbandry and medicine of pet reptiles. In Birchard SJ, Sherding RG eds.: Saunders Manual of Small Animal Practice 3rd ed. Philadelphia: W.B. Saunders, pp. 1910-1942.
2005. Padgett KA, Reisen W, Cahoon-Young B, Carney L, Woods L, Zucca L, Anderson N, Husted S, Kramer V. West Nile virus infection in tree squirrels (Rodentia: Sciuridae) in California, 2004-2005. Poster 4th International Congress of Vector Ecology.
2004. Zabka TS, Andersen AA, Leutenegger CM, Anderson NL, Tell LA, Johnson SP, Lowenstine, LJ. A new strain of Chlamydiophila psittaci, Strain G, isolated from red tailed hawks (Buteo jamaicensis): Identification, prevalence, diagnostic testing, and pathology. 2004 Proceedings AAZV, AAWV, WDA Joint Conference, 440-444.
2000. Anderson NL, Wack RF. Anesthetic procedures in exotic pets. In Muir W, Hubbell J eds.: Handbook of Veterinary Anesthesia 3rd ed. St. Louis: C.V. Mosby Company, pp. 372-408.
2000. Anderson NL. Pet rodents. In Birchard SJ, Sherding RG eds.: Saunders Manual of Small Animal Practice 2nd ed. Philadelphia: W.B. Saunders, pp. 1512-1538.
2000. Anderson NL, Wack RF. Basic husbandry and medicine of pet reptiles. In Birchard SJ, Sherding RG eds.: Saunders Manual of Small Animal Practice 2nd ed. Philadelphia: W.B. Saunders, pp. 1539-1567.
1999. Miller RE, Anderson NL. Immunization of wild animal species against common diseases. In Bonagura JD (ed.): Current Veterinary Therapy XIII. Philadelphia: W.B. Saunders Co..
1997. Anderson NL. Diseases of Iguana iguana. In Rosenthal K ed.: Exotic Animal Medicine in Practice. Trenton, New Jersey: Veterinary Learning Systems, pp.14-19.
1997. Anderson NL. Husbandry and clinical evaluation of Iguana iguana. In Rosenthal K ed.: Exotic Animal Medicine in Practice. Trenton, New Jersey: Vet Learning Sys, pp. 20-26.
1997. Anderson NL. Case studies. In Rosenthal K, Brown S ed.: Self-Assessment Colour Review of Small Mammals. London: Manson Publishing Ltd., pp. 5,6,9,10,21,22,45,46,49,50.
1995. Anderson NL. Intraosseous fluid therapy in small exotic animals. In Bonagura JD, Kirk RW eds.: Kirk's Current Veterinary Therapy XII. Philadelphia: W.B. Saunders Company, pp. 1331-1335.
1995. Anderson NL, Wack RF. Anesthetic procedures in exotic pets. In Muir W, Hubbell J eds.: Handbook of Veterinary Anesthesia. St. Louis: C.V. Mosby Company, pp. 341-371.
1994. Anderson NL. Basic husbandry and medicine of pocket pets. In Birchard SJ, Sherding RG eds.: Saunders Manual of Small Animal Practice. Philadelphia: W.B. Saunders, pp. 1363-1389.

Professional Presentations

2015. Anderson NL. Field Stabilization Program Can Enhance Survival of Seabirds During Oil

Spill Response. 2015 Proc. Effects of Oil on Wildlife Conf., Anchorage, AK Pp. 17-31.

2014. Anderson NL. Development of Field Stabilization Program to Enhance Survival of Seabirds During Oil Spill Response. 2014 Proc. International Oil Spill Conf., Savannah, GA Pp. 1545-1558.

2012. Anderson, NL, Ziccardi M. Oiled Wildlife Care Network: A Public, private, not-for-profit partnership. Environmental Response to Oil Spills in California (EROS) Training. Monterey Bay CA.

2009. Anderson NL, Grahn RA, Van Hoosear KA, BonDurant RH. Clinicopathologic features of trichomonad infections in free ranging finches, mockingbirds, and corvids in northern California. UC Davis 15th Annual WAAM Wildlife Medicine Symposium.

2009. Anderson NL. Late Stage Granulomatous Interstitial Pneumonia Secondary to Near-drowning in an Osprey (Pandion haliaetus) UC Davis 15th Annual WAAM Wildlife Medicine Symposium.

2008. Anderson NL, Grahn RA, Van Hoosear KA, BonDurant RH. Avian trichomoniasis. AAZV, Los Angeles, CA

2007. Anderson NL. Wildlife rehabilitation. California State University, Concord, CA

2006. Anderson NL. Dealing with head trauma in wildlife. Ross Veterinary School, St. Kitts

2006. Anderson NL. Amphibian diseases. Ross Veterinary School, St. Kitts

2006. Anderson NL. Reptile diagnostic techniques. Ross Veterinary School, St. Kitts

2006. Anderson NL. West Nile Virus: A wildlife rehabilitation vet's clinical experience. UC Davis 12th Annual WAAM Wildlife Medicine Symposium.

2005. Anderson NL, Whited, L. Pain management. California Council of Wildlife Rehabilitators Annual Meeting. Reading, CA.

2005. Anderson NL. Dealing with head trauma. California Council of Wildlife Rehabilitators Annual Meeting and Region 3 Meeting California Department of Fish and Game.

2004. Anderson NL. Use of antibiotics in wildlife. California Council of Wildlife Rehabilitators Annual Meeting. Yosemite, CA.

2002. Anderson NL. Trichomonas in house finches and corvids in the East Bay area of California. Proc International Wildlife Rehabilitators Council. Concord, CA.

2002. Anderson NL. Avian hematology. Proc International Wildlife Rehabilitators Council. Concord, CA.

2002. Anderson NL. Avian radiology. Proc International Wildlife Rehabilitators Council. Concord, CA.

2000. Anderson NL, Hetherington T, Williams J. Indirect calorimetry studies of brown treesnakes (Boiga irregularis) at 20 C, 25 C, 30 C, and 35 C. ASIH, SSAR, HL AES, NIA, and CAH Annual Meeting. La Paz, Mexico.

2000, 1999. Anderson NL. Reptile Medicine Series. Purdue University College of Veterinary Medicine, Lafayette, Indiana

1999. Anderson NL. The brown tree snake dilemma. The Kansas City Herpetological Society, Kansas City, Missouri

1998. Anderson NL, Hetherington T, Coupe B, Perry G, Williams J. Field and laboratory studies of temperature and water balance physiology of the brown treesnake: I. Temperature preferences and temperature characteristics of refugia. 1998 Brown treesnake Research

Symposium. Honolulu, HI, p. 9.

1998. Anderson NL, Hetherington T, Williams J, Coupe B, Perry G. Field and laboratory studies of temperature and water balance physiology of the brown treesnake: II. Water flux rates and susceptibility to desiccation. 1998 Brown treesnake Research Symposium. Honolulu, HI, p. 9.

1998. Anderson NL, Wack RF, Burke L, Hetherington T, Williams J. Assessment of propofol as an anesthetic agent in brown treesnakes, Boiga irregularis. Proc 5th Annual Conf Assoc Reptilian and Amphibian Veterinarians. Kansas City, MO, pp. 29 – 31.

1998. Perry G, Coupe B, Anderson N, Hetherington T. Daily refugia of brown tree snakes on Guam: location choice and thermal implications. Proc ASIH, SSAR, HL AESAM and Canadian Assoc. Herpetologists Annual Meeting. Guelph, Canada, p. 585.

1998. Anderson NL, Coupe B, Perry G, Hetherington T, Williams J. Field and laboratory studies on active and resting body temperatures of a nocturnal, tropical snake (Boiga irregularis). Proc ASIH, SSAR, HL, AESAM, and Canadian Assoc. Herpetologists Annual Meeting. Guelph, Canada, p. 461.

1998. Anderson NL, Coupe B, Hetherington T, Williams J. Field use of propofol: Finally a safe, effective, rapid recovery anesthetic for reptiles. Proc ASIH, SSAR, HL, AESAM, and Canadian Assoc. Herpetologists Annual Meeting. Guelph, Canada, p. 506.

1997. Anderson NL. Exotic animal medicine series. Tokyo and Osaka, Japan.

1995, 1993. Anderson NL and Wack RF. Avian hematology laboratory and wildlife rehabilitation assistance. Guatemala City, The Peten region, and the Pacific coast region, Guatemala.

1997. Anderson NL. Use of intraosseous fluids in wildlife rehabilitation. 1997 Annual Proceedings of the National Wildlife Rehabilitators Association. Columbus, Ohio.

1996. Anderson, NL. The Effects of Temperature, Sex, and Sample Type on Hematology and Serum/Plasma Chemistry Values for Captive New Guinea Snapping Turtles (Elseya novaeguineae). Annual Proceedings of the Association of Reptilian and Amphibian Veterinarians. Tampa, Florida. Pp. 43 - 50.

1996. Anderson, NL. Ovarian Teratoma in a Green Iguana (Iguana iguana). Annual Proceedings of the Association of Reptilian and Amphibian Veterinarians. Tampa, Florida. Pp. 127 - 130.

1996. Anderson, NL. Intraosseous fluid therapy. Annual Proceedings of OVMA. Columbus, Ohio

1996. Anderson, NL. Rabbit/ ferret behavior. Annual Proceedings of OVMA. Columbus, Ohio.

1996. Anderson, NL. Diseases of iguanas. Annual Proceedings of OVMA. Columbus, Ohio.

1996. Anderson, NL. Anorexia in reptiles. Annual Proceedings of OVMA. Columbus, Ohio.

1995. Anderson, NL. Avian hematology and serum chemistry. An Proc of AAV: Introduction to Clinical Avian Medicine Proceedings. Philadelphia, Pennsylvania. P. 47-57.

1995. Anderson, NL. Avian Radiology. Annual Proceedings of WEZAM. Madison, Wisconsin.

1995. Anderson, NL. Avian Dermatology. Annual Proceedings of WEZAM. Madison, WI.

1995. Anderson, NL. Basic Avian Techniques. Annual Proceedings of WEZAM. Madison, WI.

1995. Anderson, NL. Head trauma in wildlife. Proc OWRA Annual Meeting. Columbus, OH.

1994. Anderson, NL. Successful treatment of urolithiasis associated with a fungal cystitis in Iguana iguana. Annual Proceedings of ARAV/AAZV. Pittsburg, PA. Pp. 52 - 56.

1993. Anderson NL. Stabilization of wildlife species. Proc OWRA An Meeting. Columbus, OH.

1992. Anderson, NL. Exotic Animal Anesthesia. Proceedings OSU Anesthesia Short course. Columbus, OH.

1991. Anderson, NL. Feather Picking. Midwest Avian Research Expo. Cleveland, OH. P. 74-83.

Research Funding

Effects of glucose and gavage temperature on warming of hypothermic seabirds
Oiled Wildlife Care Network
Status: Principle Investigator
Amount: [redacted]
Start date: October 2014 End date: June 2017

Ecophysiological studies of brown treesnakes
Biological Resources Division of United States Geological Service and
The Kansas City Herpetological Society Research Grant
Status: Co-Investigator
Principle Investigator: Thomas E. Hetherington PhD
Amount: [redacted]
Start date: July 1997 End date: September 2000

Calcium-Regulating Hormones and Bone Remodeling in Green Iguanas (Iguana iguana)
Columbus Zoo/Ohio State University Co-operative Research Grant Program
Status: Co-Investigator
Principle Investigator: Thomas J. Rosol, DVM, PhD
Amount: [redacted]
Start date: July 1997 End date: June 1998

Hematology and serum/plasma chemistry normals for captive Elseya novaguineae
(The New Guinea snapping turtle) held at 75 F and 85 F
Columbus Zoo Research Grant Program: Animal Management Health and
Scientific Studies Committee
Principal investigator: Nancy Anderson, DVM, ABVP (Avian)
Amount: [redacted]0
Start date: June 1994 End date: June 1995

Clinical Field Trial of Chewable Milbemycin
Ciba-Geigy Animal Health
Principal investigator: Nancy Anderson, DVM
Amount: [redacted]
Start date: January 1993 End date: January 1994

CURRICULUM VITAE

BRIAN BOYCE HATFIELD

USGS – WERC
Santa Cruz Field Station
Piedras Blancas Light Station Office
P.O. Box 70
San Simeon, CA 93452
Phone: (805) 305-2121

EDUCATION

1977 – 1979	California Polytechnic State University San Luis Obispo, California Master of Science in Biology, August 1979
1971 – 1975	University of California, Santa Cruz Bachelor of Arts, June 1975 Graduation with Honors in Biology

EXPERIENCE

Wildlife Biologist California Sea Otter Project October 1990 – Present	U.S. Geological Survey Piedras Blanc Office, Santa Cruz Field Station P.O. Box 70 San Simeon, CA 93452 (805) 927-3893
Biological Technician California Sea Otter Project January 1987 – October 1990	U.S. Fish and Wildlife Service Piedras Blancas Field Station P.O. Box 70 San Simeon, CA 93452 (805) 927-3893
Sea Otter Research Technician June 1984 – March 1987	Dr. Don Siniff University of Minnesota Piedras Blancas Field Station P.O. Box 70 San Simeon, CA 93452 (805) 927-5480
Biologist, Consultant October 1984 – April 1985	Marine Mammal Commission 1625 Eye Street, NW, Rm. 307 Washington, D.C. 20006 (202) 653-6237
Fish and Wildlife Seasonal October 1983 – June 1984	California Dept. of Fish and Game 213 B Beach Street Morro Bay, CA 93442

	(805) 772-3011
Biologist, Consultant February – July 1983	California Dept. of Fish and Game Diablo Canyon Ecological Studies P.O. Box 98, Avila Beach, CA 93424 (805) 595-7363
Junior College Instructor August 1982 – May 1983	Allan Hancock College 800 South College Drive Santa Maria, CA 93454 (805) 922-6966
Fish and Wildlife Seasonal March – December 1982	California Dept. of Fish and Game Diablo Canyon Ecological Studies P.O. Box 98, Avila Beach, CA 93424 (805) 595-7363
Fisheries Technician July – November 1980 & 1981	Pacific Marine Fisheries Commission c/o California Dept. of Fish and Game 213 B Beach Street Morro Bay, CA 93442 (805) 772-3011
Marine Biology Instructor February – June 1981	Catalina Island Marine Institute P.O. Box 796 Avalon, CA 90794 (213) 510-1622
Fish and Wildlife Seasonal December 1979 – June 1980	California Dept. of Fish and Game 213 B Beach Street Morro Bay, CA 93442 (805) 772-3011
Sea Otter Field Biologist July – December 1978	Dr. Aryan Roest Biological Sciences Department California Polytechic State University San Luis Obispo, CA (805) 546-2788

SPECIAL SKILLS

1982 Specialty Diver Certification, California Department of Fish and Game

1984 Training in underwater capture of sea otters, Calif. Dept. Fish and Game

1990 Closed circuit oxygen rebreather certification

PUBLICATIONS

HATFIELD , B.B., J.L. YEE, M.C. KENNER, J.A. TOMOLEONI, AND M.T. TINKER , 2018, California sea otter(*Enhydra lutris nereis*) census results, spring 2018: U.S. Geological Survey Data Series 1097, 10 p., https://doi.org/10.3133/ds1097

TINKER, M.T. AND B.B. HATFIELD. 2017, California sea otter (Enhydra lutris nereis) census results, spring 2017: U.S. Geological Survey Data Series 1067, 9 p., https://doi.org/10.3133/ds1067.

HATFIELD, B.B. AND P. UNITT. 2017. Southern sea otter, Enhydra lutris nereis. Pages 306-307 in Tremor, S., D. Stokes, W. Spencer, J. Diffendorfer, H. Thomas, S. Chivers, and P. Unitt, editors. San Diego County Mammal Atlas. Proceedings of the San Diego Society of Natural History 46.

TINKER, M.T. AND B.B. HATFIELD. 2016, California sea otter (*Enhydra lutris nereis*) census results, spring 2016: U.S. Geological Survey Data Series 1018, 10 p., http://dx.doi.org/10.3133/ds1018

TINKER, M.T., B.B. HATFIELD, M.D. HARRIS, and J.A. AMES. 2015. Dramatic increase in sea otter mortality from white sharks in California: Marine Mammal Science, v. 32, no. 1, p. 309–326, doi:10.1111/mms.12261.

LOWRY, M.S., R.CONDIT, B.B. HATFIELD, S.G. ALLEN, R. BERGER, P.A. MORRIS, B.J. LeBOEUF, AND J. REITER. 2014. Abundance, Distribution, and Population Growth of the Northern Elephant Seal (*Mirounga angustirostris*) in the United States from 1991 to 2010**.** *Aquatic Mammals* 2014, *40*(1), 20-31, DOI 10.1578/AM.40.1.2014.20

KENNER, M.C., J.A. Estes, M. TIM TINKER, J.L. BODKIN, R.K. COWEN, C. HARROLD, B.B. HATFIELD, M. NOVAK, A. RASSWEILER, and D.C. REED. 2013. A multi-decade time series of kelp forest community structure at San Nicolas Island, California (USA). Ecology 94:2654. http://dx.doi.org/10.1890/13-0561.1

HATFIELD, B.B., J.A. AMES, J.A. ESTES, M.T. TINKER, A.B. JOHNSON, M.M. STAEDLER, AND M.D. HARRIS. 2011. Sea otter mortality in fish and shellfish traps: estimating potential impacts and exploring possible solutions. Endangered Species Research 13(3):219-229

MILLER, M.A.., P.A. CONRAD, M. HARRIS, B. HATFIELD, G. LANGLOIS, D.A. JESSUP, S.L. MAGARGAL, A.E. PACKHAM, S. TOY-CHOUTKA, A.C. MELLI, M.A. MURRAY, F.M. GULLAND, AND M.E. GRIGG. 2010. A protozoal-associated epizootic impacting marine wildlife: mass-mortality of southern sea otters (Enhydra lutris nereis) due to Sarcocystis neurona infection. Veterinary Parasitology 172:183-197.

TINKER, M. T., D. F. DOAK, J. A. ESTES, B. B. HATFIELD, M. M. STAEDLER, AND J.L. BODKIN. 2006. Incorporating diverse data and realistic complexity into demographic estimation procedures for sea otters. Ecological Applications 16(6):2293-2312.

HATFIELD, B. B. 2005. The translocation of sea otters to San Nicolas Island: an update. Pp.473-475 in D.K. Garcelon and C.A. Schwemm eds., Proceedings of the Sixth California Islands Symposium, Ventura, California, December 1-3, 2003.

ESTES, J. A., B. B. HATFIELD, K. RALLS, AND J. AMES. 2003. Causes of mortality in California sea otters during periods of population growth and decline. Marine Mammal Science 19:198-216.

RATHBUN, G. B., B. B. HATFIELD, AND T. G. MURPHEY. 2000. Status of translocated sea otters at San Nicolas Island. The Southwest Naturalist 45(3).

HATFIELD, B. B. 2000. Southern sea otter population status update. Pacific Cetacean Group Newsletter, U.C. Monterey Bay, 3239 Imjin Road, #122, Marina CA 93933.

HATFIELD, B. B. AND G. B. RATHBUN. 1999. Interactions between northern elephant seals and vehicles near Point Piedras Blancas, California. Marine Mammal Science 15(2):598-600.

HATFIELD, B. B. 1998, 1999, and 2000. Elephant seal populations *in* Ecosystem Observations – Annual Report for the Monterey Bay National Marine Sanctuary, 299 Foam St., Monterey CA 93940

HATFIELD, B. B., D. B. MARKS, M. T. TINKER, K. NOLAN AND J. PEIRCE. 1998. Attacks on sea otters by killer whales. Marine Mammal Science 14(4):888-894.

HATFIELD, B. B. 1998. Elephant seal populations *in* Ecosystem Observations – Annual Report for the Monterey Bay National Marine Sanctuary, 299 Foam St., Monterey CA 93940

HATFIELD, B. B. 1998. Fall 1997 sea otter survey. The Otter Raft. 59:5

HATFIELD, B. B. AND G. B. RATHBUN. 1996. Evaluation of a flipper-mounted transmitter on sea otters. Wildlife Society Bulletin 24(3):551-554.

RALLS, K., B. B. HATFIELD, AND D. B. SINIFF. 1995. Foraging patterns of California sea otters as indicated by telemetry. Canadian Journal of Zoology 73:523-531

HATFIELD, B. B., R. J. JAMESON, T. G. MURPHEY, AND D. D. WOODARD. 1994. Atypical interactions between male southern sea otters and pinnipeds. Marine Mammal Science 10(1):111-114.

HATFIELD, B. B. 1992. Notes on feeding sea otters from the Washington coast. The Otter Raft. 47:10

Brian Hatfield has been involved with sea otters since the late 1970s and has been employed with USGS (migrating from USFWS) since the mid-1980s. Currently, Brian coordinates the range-wide sea otter surveys in California, including those at San Nicolas Island, and the sea otter stranding network. He is an active sea otter capture diver and has captured and handled hundreds of sea otters in most areas where sea otters occur including in the Commander and Aleutian Islands, Prince William Sound, SE Alaska, Vancouver Island, Washington, as well as California.

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Google Scholar: https://scholar.google.com/citations?user=9HfQjCEAAAAJ&hl=en&oi=ao

POSTDOCTORAL EXPERIENCE

2018 Friday Harbor Labs Postdoctoral Fellowship
University of Washington
Mentor: Dr. Megan Dethier

2015-2017 David H. Smith Conservation Research Fellow
Duke University, University of California Santa Cruz, University of Alaska
Mentors: Drs. Brian Silliman, Ginny Eckert, Kristy Kroeker, Susan Williams

EDUCATION

2010-2014 PhD Ecology and Evolutionary Biology
University of California Santa Cruz
Advisors: Drs. Kerstin Wasson and Peter Raimondi

2003 - 2007 MS Marine Science
California State University East Bay &
Moss Landing Marine Laboratories, Moss Landing, CA
Research in Phycology, Marine Community Ecology, and Oceanography
Advisor: Dr. Michael Graham

2001 Oregon Institute of Marine Biology, Charleston, OR
Graduate courses in Marine Ecology and Marine Animal Behavior

1997 - 2001 BA Biology
Truman State University, Kirksville, MO
Advisor: Dr. Lisa Hooper

PEER-REVIEWED PUBLICATIONS *Undergraduate Researcher, #Citizen Scientist

2019

Lefcheck, J.S., **B.B. Hughes**, A.J. Johnson, B. Pfirrman, D.B. Rasher, A.R. Smyth, B.L. Williams, M.W. Beck, R.J. Orth. 2019. Coastal habitats are nurseries: a comprehensive meta-analysis. *Accepted with Revisions*. **Conservation Letters**.

2018

Silliman, B.R., **B.B. Hughes**, L.C. Gaskins, Q. He, M.T. Tinker, A. Read, J. Nifong, R. Stepp. 2018. Are the ghosts of nature past haunting conservation today? ***Current Biology***. 28:R532-R537

Toft, J., S. Munsch, J. Cordell, K. Siitari, V. Hare, B. Holycross, L. DeBruyckere, C. Greene,

B.B. Hughes. 2017. Impact of multiple Stressors on estuarine nursery function across the northeast Pacific coast. ***Global Change Biology.*** 24:2008-2020.

Jeppesen, R., *M. Rodriguez, *J. Rinde, J. Haskins, **B.B. Hughes**, L. Mehner, K. Wasson. 2018. Hypoxia increases fish mortality and reduces oyster growth in a highly eutrophic estuary*.* ***Estuaries and Coasts.*** 41:89-98

2017

Hughes, **B.B.**, S.C. Lummis, S.C. Anderson, K.J. Kroeker. 2017. Unexpected resilience of a seagrass system exposed to global stressors*.* ***Global Change Biology****.* 24:224-234.

Hughes, B.B., R. Beas-Luna, A. Barner, K. Brewitt, D.R. Brumbaugh, E. Cerny-Chipman, S.L. Close, K.E. Coblentz, K.L. de Nesnera, S.T. Drobnitch, J.D. Figurski, B. Focht, M. Friedman, J. Freiwald, K.K. Heady, W.N. Heady, A. Hettinger, A. Johnson, K.A. Karr, B. Mahoney, M.M. Moritsch, A.K. Osterback, J. Reimer, J. Robinson, T. Rohrer, J. Rose, M. Sabal, L.M. Segui, C. Shen, J. Sullivan, R. Zuercher, P.T. Raimondi, B.A. Menge, K. Grorud-Colvert, M. Novak, M.H. Carr. 2017. Long-term studies contribute disproportionately to ecology and policy. ***BioScience*** 67:271-281.

#Eby, R., #R.S. Scoles, **B.B. Hughes**, K. Wasson. 2017. Serendipity in a salt marsh: detecting frequent sea otter haul outs in a marsh ecosystem. ***Ecology.*** 98:2975-2977.

Hessing-Lewis, M., E. Rechsteiner, **B.B. Hughes**, M.T. Tinker, A. Olson, Z. Monteith, M.M. Henderson, J.C. Watson. 2017. Ecosystem features determine seagrass community response to sea otter foraging. *In press.* ***Marine Pollution Bulletin.***

Wasson, K., R. Jeppesen, C. Endris, D. Perry, A. Woolfolk, K. Beheshti, *M. Rodriguez, #R. Eby, E. Watson, F. Rahman, J. Haskins, **B.B. Hughes**. 2017. Eutrophication decreases salt marsh resilience through proliferation of algal mats*.* ***Biological Conservation****.* 212:1-11.

Honig, S., B. Mahoney, *J. Glanz, **B.B. Hughes**. 2017. Are seagrass beds indicators of anthropogenic nutrient stress in the rocky intertidal? ***Marine Pollution Bulletin*** 114:539-546.

2016

Hughes, B.B., K. Hammerstrom, N. Grant, *U. Hoshijima, #R. Eby, K. Wasson. 2016. Trophic cascades on the edge: fostering seagrass resilience via a novel pathway*.* ***Oecologia*** 182:231-241.

Wasson, K., **B.B. Hughes**, A. Chang, A. Deck, P. Dinnel, S. Dudas, M. Ferner, E. Grosholz, D. Kimbro, J. Ruesink, A. Trimble, D. Vander Schaaf, C. Zabin, D. Zacherl. 2016. Coastwide recruitment of Olympia oysters: spatial scales of synchrony and predictors of recruitment failure. ***Ecology*** 97:3503-3516.

Silliman, B.R., P.M. Dixon, C. Wobus, Q. He, P. Daleo, **B.B. Hughes,** J. Willis, M. Hester. 2016. Tipping points in marsh resilience to the Deepwater Horizon oil spill. ***Nature Scientific Reports*** 6:32520. DOI: 10.1038/srep32520.

2015 and earlier

Hughes, B.B., M. Levey, M. Fountain, A. Carlisle, F. Chavez, M. Gleason. 2015. Climate mediates threats to fish diversity and nursery function at the land-sea interface.

Proceedings of the National Academy of Sciences USA 112:8025-8030.

Hughes, B.B., #R. Eby, E. Van Dyke, M.T. Tinker, C. Marks, K.S. Johnson, K. Wasson. 2013. Recovery of a top predator mediates negative eutrophic effects on seagrass. ***Proceedings of the National Academy of Sciences USA*** **110**:1513-1518.

Hughes, B.B., J. Haskins, K. Wasson, and E. Watson. 2011. Identifying factors that influence expression of eutrophication in a central California estuary. ***Marine Ecology Progress Series*** 439:31-43.

Hughes, B.B. 2010. Variable effects of a kelp foundation species on rocky intertidal diversity and species interactions in central California. ***Journal of Experimental Marine Biology and Ecology*** 393**:**90-99.

Hernandez, G.C., **B.B. Hughes** and M. Graham. 2006. Reproductive longevity of drifting kelp *Macrocystis pyrifera* (Phaeophyceae) in Monterey Bay, USA. ***Journal of Phycology*** 42:1199-1207.

PEER-REVIEWED PUBLICATIONS *IN REVIEW* OR *IN REVISION*

Hughes, B.B. (and 20 other authors). 2018. Sea otter recolonization of estuaries leads to a rediscovery of lost opportunities. *In review*.

BOOK CHAPTERS

Silliman B., **B.B. Hughes**, Y.S. Zhang, Q. He. 2017. Business as usual leads to underperformance in coastal restoration. In: *Effective Conservation Science: Data Not Dogma.* Eds. P. Kareiva, M. Marvier, B. Silliman. Ch. 27.

THESIS & DISSERTATION

Hughes, B.B. 2014. Food webs, resilience, and functioning of an estuary under multiple threats: lessons learned from Elkhorn Slough. Ph.D. Dissertation. University of California, Santa Cruz. 164 pages.

Hughes, B.B. 2007. Effects of *Egregia menziesii* on intertidal benthic assemblages. MS Thesis. California State University East Bay, Hayward. 124 pages.

TECHNICAL REPORTS

Hughes, B.B. Estuarine & Wetland Ecosystems: the first steps in developing an approach to leveraging existing monitoring programs. Report to California Ocean Science Trust, Oakland, CA USA. June, 2017.

Hughes, B.B., C. Endris, K. Beheshti, M.T. Tinker, S.L. Williams, H.G. Greene. 2016. Enhancement of healthy coastal environments by incorporating species interactions into seagrass mitigation design. California SeaGrant Report. Project # R/HCME-18PD. 23 pp.

Hughes, B.B., M.D. Levey, J.A. Brown, M.C. Fountain, A.B. Carlisle, S.Y. Litvin, C.M. Greene, W.N. Heady, M.G. Gleason. 2014. Nursery functions of U.S. west coast estuaries: the state of knowledge for juveniles of focal fish and invertebrate species. *The Nature Conservancy*, Arlington, VA. 168 pp.

Hughes, B.B., M. Fountain, A. Carlisle, M. Levey, M. Gleason. 2012. The impacts of nutrient loading and environmental conditions on the fish assemblage and available nursery habitat in Elkhorn Slough. *The Nature Conservancy*.

Hughes, B.B., J. Haskins, K. Wasson. 2010. Assessment of the effects of nutrient loading in estuarine wetlands of the Elkhorn Slough watershed: a regional eutrophication report card. *Elkhorn Slough Technical Report Series* 2010:1.

Hughes, B.B. 2009. Synthesis for management of eutrophication issues in Elkhorn Slough. *Elkhorn Slough Technical Report Series* 2009:1.

Stepehnson, M., J. Negrey, **B.B. Hughes**. 2009. Spatial and temporal trends of methyl mercury in California bays and harbors: A bioaccumulation approach to assess fish and water quality. *California State Water Resources Control Board Technical Report.*

Stephenson, M., W. Heim**, B.B. Hughes**, A. Bonnema and K. Coale. 2008. Methylmercury loading studies in Delta wetlands. *CALFED Mercury Project*, Task 5.3a.

POPSCI ARTICLES

Hughes, B.B. 2017. Searching for the southern sea otter. Lost and Found Blog. http://www.lostandfoundnature.com/blog/2017/08/18/searching-for-the-southern-sea-otter/

Hughes, B.B. River otters in a land without rivers. 2018. San Juan Islander. https://sanjuanislander.com/opinion/columnists/tide-bites/27960/river-otters-in-a-land-without-rivers

*Ali, B., *N. Noor, *S. Soto, **B.B. Hughes.** River otters lurking in the sea: further evidence of a paradigm shift in conservation. 2018. Society for Conservation Biology News Blog. https://conbio.org/publications/scb-news-blog/river-otters-lurking-in-the-sea-further-evidence-of-a-paradigm-shift-in-con

PRESS

For links to selected media coverage of my research go to: http://hughesecology.com/in-the-news/

Hughes et al. (2017) BioScience: Highlighted on the BioScience cover, Oregon State University, UC Santa Cruz

Hughes et al. (2015) PNAS: Highlighted on the PNAS cover, Highlighted in commentary by Nancy Rabalais PNAS, Newsweek, Science Daily, American Fisheries Society, UC Santa Cruz, Santa Cruz Sentinel, PNAS Blog, Monterey County Herald

Hughes et al. (2013) PNAS and associated sea otter research: National Geographic, BBC, NPR, Al Jazeera, LA Times, Science Daily, Huffington Post, Christian Science Monitor, The Australian, The Guardian, Mongabay, BioScience, The China Post, UC Santa Cruz, Santa Cruz Sentinel, PNAS Blog, French Tribune, Science Recorder, The Inquisitir, Monterey County

Herald, Nature Conservancy Magazine, Southern California Public Radio, Canadian Broadcasting Company Radio, Lost and Found Blog

Hughes et al. (2011) MEPS: Santa Cruz Sentinel, UC Santa Cruz

GRANTS & PI EXPERIENCE

California Coastal Conservancy. Determining habitat extent and population growth of sea otter recolonization of northern California. [redacted]. 2019-2020. PI: **BB Hughes**.

Koret Scholars Award. Scale-dependency in coastal food webs along the California Current. [redacted]. 2019. PI: **BB Hughes** (Awarded with 4 undergraduates at SSU).

Anthropocene Institute. Enhancing restoration design of imperiled Olympia oysters in a highly degraded estuary [redacted]. 2017-2018. PIs: **BB Hughes**, K. Wasson.

NSF BIO-OCE. Trophic linkages in seagrass ecosystems. [redacted]. 2016-2019. PI: G Eckert, Senior Personnel: T. Tinker, **BB Hughes.**

California Ocean Science Trust. Estuarine & Wetland Ecosystems Monitoring Program Integration. [redacted]. 2016-2017. PI: **BB Hughes.**

The Ocean Foundation. Ecosystem functioning of restored seagrass beds. [redacted] 2016-2017. PI: **BB Hughes.**

Anthropocene Institute/Ocean Foundation, "Restoration of eelgrass to and its effects to key ecosystem services and water quality". [redacted]2016-2017. PI: **BB Hughes**.

California Sea Grant, "Enhancement of healthy coastal environments by incorporating species interactions into seagrass mitigation and restoration design", [redacted] 2015-2016. PI: HG Greene. **BB Hughes, Ghost author and project leader**.

The Nature Conservancy Grant "Nursery Functions of West Coast Estuaries: A State of the Knowledge Report" [redacted], 2013-2014. PIs: **BB Hughes**, J Brown, M Levey, A Carlisle, S Litvin, M Fountain

Central Coast Regional Water Quality Control Board Grant "Discharge measurements for the Tembaldero Slough: determining nutrient loading to Elkhorn Slough" [redacted] 2014. PIs: J Haskins, **BB Hughes**

The Nature Conservancy Grant "Investigation of the relationship between the nursery function of estuaries and nutrient loading", [redacted]0, 2012. PIs: **BB Hughes,** M Fountain, M Levey, A Carlisle

NOAA Recovery and Reinvestment Act via the Elkhorn Slough Tidal Wetland Program for eutrophication research and monitoring[redacted], 2010-11.

Earl and Ethel Meyers Foundation Grant for research [redacted], 2011

David and Lucile Packard Foundation Grant for research [redacted] 2005

PADI Foundation Grant for research [redacted], 2005

Earl and Ethel Meyers Foundation Grant for research [redacted] 2005

FELLOWSHIPS & AWARDS

University of Washington, Friday Harbor Labs Postdoctoral Fellowship [redacted], 2018-2019

David H. Smith Postdoctoral Conservation Fellowship [redacted] 2015-2017

NOAA - Walter B. Jones Memorial Award for Excellence in Coastal and Marine Graduate Study, 2014

NOAA National Estuarine Research Reserve Graduate Research Fellowship [redacted] 2011-2014

Rebecca and Steve Sooy Fellowship in Marine Mammals [redacted] 2014

UCSC Department of Ecology and Evolutionary Biology Research Awar [redacted] 2014

UCSC Department of Ecology and Evolutionary Biology Research Awar [redacted] 2013

UCSC Department of Ecology and Evolutionary Biology Research Awar [redacted] 2012

Friends of Long Marine Laboratory Student Research Award [redacted], 2012

UCSC Department of Ecology and Evolutionary Biology Research Award [redacted] 2011

UCSC STARS Re-entry Student Scholarship [redacted], 2011

Friends of Long Marine Laboratory Student Research Award [redacted], 2011

Coastal and Estuarine Research Federation Student Travel Award [redacted] 2011

California Estuarine Research Society Student Travel Award [redacted] 2011

2nd place Student Poster Award, Northwest Algal Symposium 2005

Americorps Academic Scholarship [redacted] August 2001

RESEARCH EXPERIENCE

2008 - 2014 *Estuarine Ecologist*, Elkhorn Slough National Estuarine Research Reserve, Watsonville, CA.

2008 - 2013 *Research Diver*, Sandoval and Associates, Salinas, CA.

2005 - 2008 *Research Analyst*, Moss Landing Marine Labs, Moss Landing, CA.

2006 - 2008 *Consultant*, Carlsbad Aquafarm, Carlsbad, CA.

2002 - 2007 *Research Assistant*, Moss Landing Marine Labs, Moss Landing, CA

2000 - 2001 *Independent Research*, Truman State University, Kirksville, MO
"Light induced inhibition of *Myxococcus xanthus* development"

1999 - 2000 *Research Assistant*, Truman State University, Kirksville, MO

TEACHING EXPERIENCE (Instructor or co-instructor)

2018-present *Faculty*, Sonoma State University, courses taught: Ecology, Marine Ecology, Intro to R
2016 *Course Co-Instructor*, Duke University, Marine Ecology field course
2015 *Course Co-Instructor*, University of California Santa Cruz, Marine Conservation Biology class
2008 - 2010 *Adjunct Faculty*, Cabrillo College, courses taught: Ecology
2005 *Instructor*, MLML Teacher Enhancement Program, taught high school marine botany in Watsonville, CA.

Invited Lectures and TAships

2017 *Invited Lecturer*, Stanford University, Exploring the Critical Interface Between the Land and Monterey Bay: Elkhorn Slough
2016 *Invited Lecturer*, Duke University, Marine Ecology class
2016 *Invited Lecturer*, University of California Santa Cruz, Marine Ecology class
2015 *Invited Lecturer*, Duke University, Marine Mammals class
2015 *Invited Lecturer,* University of California Santa Cruz, Marine Botany class
2014 *Invited Lecturer,* University of California Santa Cruz, Ecology class
2014 *Invited Lecturer,* University of California Santa Cruz, Marine Ecology class
2014 *Invited Lecturer,* University of California Santa Cruz, Marine Botany class
2013 *Invited Lecturer,* University of California Santa Cruz, Marine Botany class
2012 *Invited Lecturer*, Stanford University, Human Ecology class
2012 *Invited Lecturer*, Moss Landing Marine Labs, Chemical Oceanography class
2012 *Invited Lecturer*, University of California Santa Cruz, Marine Botany class
2012 *Invited Instructor*, Elkhorn Slough National Estuarine Research Reserve's Coastal Training Program. Workshop on water quality issues in Monterey Bay, CA
2012 *Invited Instructor* for the Monterey Area Research Institutions' Network for Education (MARINE) workshop on water quality issues in Elkhorn Slough, CA
2011 *Invited Lecturer*, University of California Santa Cruz Marine Botany class
2010 - 2014 *Teaching Assistant,* University of California Santa Cruz, Courses: Cell and Molecular Biology, Life in the Sea, Marine Botany (3x), Plant Physiology, Ecology and Evolution
2010 *Invited Lecturer*, Cabrillo College Ecology class
2009 -present *Research Mentor* for 21 students from California State University Monterey Bay's Undergraduate Research Opportunities Center (UROC), Hartnell College, the University of California Santa Cruz, Duke University and Stanford University
2002 - 2005 *Teaching Assistant*, Moss Landing Marine Labs, Courses: Kelp Ecology and Marine Ecology, assisted in designing lectures for Marine Botany

Mentored Students (G = Graduate, U = Undergraduate)

University of California Santa Cruz – Kathryn Beheshti (G), Sean Abby (U), Jessica Glanz, (U), Umi Hoshijima (U), Brett Bulkin (U), Leo Hijikata (U), Scott Borsom (U), Erica Ferrer (U), Tanya Guzman, (U), Luis Hernandez (U), Caitlin Seyfried (U), Nicole D'Antonio (G), Adri Sparks (U), Anthea Fredrickson (U), Daniel Inglese (U), Stephanie Douglas (U)
CSU Monterey Bay – Miguel Rodriguez (U), Jared Worland (U), Lizz Johnson (U), Jenna Van Parys (U)
Stanford University – Ju Lee (G)
University of Arizona - Abby Gritis (U, 2017 Doris Duke Scholar)
St. Olaf – Bashir Ali (U, 2018 Doris Duke Scholar)
UC Berkeley – Soledad Soto (U, 2018 Doris Duke Scholar)
University of Florida – Nusrat Noor (U, 2018 Doris Duke Scholar)

Duke University – Lindsay Gaskins (G, committee member)
San Diego State University – Tracy Grimes (G)
University of Alaska Fairbanks – Wendel Raymond (G)
San Francisco State University Jane Rudebusch (G, committee member)
Sonoma State: Aanisah Houston (U), Lauren Bocca (U), Jessica Saavedra (U), Natasha Higuera (U)

INVITED SEMINARS and TALKS

Hughes, B.B. Sep 2018. Sea otters and estuaries: paradise lost. *Invited public seminar*. Sea Otter Awareness Week. Morro Bay, CA.

Hughes, B.B., D. Gossard, P. Hain, M.H. Graham, K. Wasson. Aug 2018. Aquaculture as a tool for restoring native oysters and understanding lost species interactions. *Invited talk*. Pathways Toward Responsible Aquaculture in California Workshop. Moss Landing Marine Labs, Moss Landing, CA.

Hughes, B.B., S. Lummis, K. Kroeker, S. Anderson. June 2018. Resilience of a seagrass system exposed to ocean acidification and nutrient enrichment. *Invited talk*. ASLO 2018 Summer Meeting.

Hughes, B.B. March 2018. Food webs, resilience, and functioning of coastal ecosystems. *Invited Seminar*. University of Washington, Friday Harbor Labs.

Hughes, B.B. March 2018. Food webs, resilience, and functioning of coastal ecosystems. *Invited Seminar*. Florida State University Coastal and Marine Laboratory.

Hughes, B.B. March 2018. Food webs, resilience, and functioning of coastal ecosystems. *Invited Seminar*. University of Chicago, Marine Biology Laboratory.

Hughes, B.B. March 2018. Food webs, resilience, and functioning of coastal ecosystems. *Invited Seminar*. University of Alaska Fairbanks.

Hughes, B.B. February 2018. Food webs, resilience, and functioning of coastal ecosystems. *Invited Seminar*. Sonoma State University, Biology Department.

Hughes, B.B. February 2018. Food webs, resilience, and functioning of coastal ecosystems. *Invited Seminar*. California State University East Bay, Biology Department.

Hughes, B.B. May 2017. Food webs, resilience, and functioning of coastal ecosystems. *Invited Webinar*. Canadian Society of Environmental Biologists.

Hughes, B.B. April 2016. Food webs, resilience, and functioning of coastal ecosystems under threat from multiple anthropogenic stressors. *Invited Seminar*. University of California Santa Cruz, Ocean Science Department.

Hughes, B.B. March 2016. Food webs, resilience, and functioning of coastal ecosystems. *Invited Seminar*. University of Florida.

Hughes, B.B., M. Fountain, A. Carlisle, M. Gleason, M. Levey. February 2016. Climate mediates threats to fish diversity and nursery function at the land-sea interface. *Invited Talk*

Ocean Sciences Meeting.

Hughes, B.B., M. Fountain, A. Carlisle, M. Gleason, M. Levey. November 2015. Climate mediates threats to fish diversity and nursery function at the land-sea interface. *Invited Talk* Coastal and Estuarine Research Federation Biennial Conference.

Hughes, B.B. October 2015. Food webs, stability, and functioning of nearshore and estuarine ecosystems in the northeast Pacific. *Invited Seminar*. Monterey Bay Aquarium Research Institute.

Hughes, B.B. September 2015. Can sea otters defend and restore our coastlines? *Invited Seminar*. Duke Marine Lab.

Hughes, B.B. April 2015. Food webs, stability, and functioning of nearshore and estuarine ecosystems in the northeast Pacific. *Invited Seminar*. University of Washington, School of Aquatic and Fishery Sciences.

Hughes, B.B. March 2015. Food webs, resilience, and functioning of an estuary under multiple threats: lessons learned from Elkhorn Slough. *Invited Seminar.* Moss Landing Marine Laboratories.

Hughes, B. T. Tinker. November 2014. Oral Presentation. From kelp forests to pickle weed: sea otter effects on ecosystem dynamics in two distinct coastal habitats. Presented to the staff for Monterey Bay Aquarium's Conservation Science Seminar Series.

Haskins, J., **B. Hughes**, K. Wasson. March 2014. Oral Presentation. *Invited Public Seminar*. Long-term water quality monitoring and eutrophication research at Elkhorn Slough. Presented to the Central Coast Regional Water Quality Control Board. Salinas, CA.

Hughes, B. The surprising case of the reappearing seagrass. November 2013. Oral Presentation. *Invited Public Seminar.* Elkhorn Slough Foundation.

Hughes, B. Can sea otters mediate the harmful effects of nutrient pollution on seagrass? September 2012. Oral Presentation. *Invited Public Seminar*. Sea Otter Awareness Week, California State University, Monterey Bay.

Hughes, B. Linking watershed activities to nearshore ecosystem processes: a case study of Elkhorn Slough. February 2012. *Invited Seminar*. California State University Monterey Bay, Division of Science and Environmental Policy.

CONTRIBUTED PAPERS

Hughes, B., K. Beheshti, L. Carswell, B. Silliman, M. Tinker, S. Williams. Are sea otters the solution for coastal restoration in the North Pacific? July 2017. Oral Presentation. International Congress for Conservation Biology; Cartagena, Colombia.

Hughes, B., K. Beheshti, C. Angelini, T. Tinker, K. Wasson, B. Silliman. Top predator recovery suppresses die-back of shoreline-protecting salt marshes through a trophic cascade. January 2017. Oral Presentation Elkhorn Slough Research Symposium.

Hughes, B., K. Beheshti, C. Angelini, T. Tinker, B. Silliman. Top predator recovery suppresses die-back of shoreline-protecting salt marshes through a trophic cascade. November 2016. Oral presentation. Western Society of Naturalists.

Hughes, B., K. Beheshti, C. Angelini, T. Tinker, K. Wasson, B. Silliman. Sea otter expansion in estuaries can trigger system-wide recovery. March 2016. Oral Presentation. Southern Sea Otter Research Alliance Meeting. University of California, Santa Cruz.

Hughes, B. The return of sea otters to estuaries, implications for ecosystem resilience, functioning, and conservation. February 2014. Oral Presentation. Southern Sea Otter Research Alliance Meeting. University of California, Santa Cruz.

Levey, M.D., **B. Hughes**. Mapping the implications of low oxygen (hypoxia) on available habitat for select species of flatfish in Elkhorn Slough. November 2013. Oral Presentation. ESRI Ocean GIS Forum. Redlands, California, USA.

Hughes, B. Why is the estuary green and why should we care? January 2013. PhD Proposal Seminar. University of California, Santa Cruz.

Hughes, B., R. Eby, E. Van Dyke, K. Wasson. 2012. Sea otters mediate negative eutrophication effects on seagrass through a multi-level trophic cascade. November 2012. Oral Presentation. Western Society of Naturalists.

Hughes, B., M. Fountain, A. Carlisle, M. Levey, and M. Gleason. Synergistic effects of eutrophication and large-scale climatic patterns on an estuarine fish assemblage. September 2012. Oral Presentation. California Estuarine Research Society Meeting.

Hughes, B. The role of scale when determining the relative importance of bottom-up forces and species interactions on seagrass populations. December 2011. Oral Presentation. Species Interaction Workshop, Stanford University.

Hughes, B., J. Haskins, K. Wasson, E. Watson. 2011. Identifying factors that influence expression of eutrophication in a central California estuary. November 2011 Oral presentation. Coastal and Estuarine Research Federation Biennial Conference.

Hughes, B., J. Haskins, K. Wasson. Eutrophication assessment of Elkhorn Slough, CA. February 2010. Poster Presentation. National Estuarine Research Reserve Annual Technical Meeting.

Hughes, B., K. Wasson, and J. Haskins. Patterns and filters of eutrophication endpoints in Elkhorn Slough. January 2010. Oral presentation. Elkhorn Slough Research Symposium.

Hughes, B., K. Wasson, J. Haskins. Spatial variability in eutrophication indicators across a tidal gradient in Elkhorn Slough, CA. November 2009. Oral presentation. Coastal and Estuarine Research Federation Biennial Conference.

Hughes, B. Effects of *Egregia menziesii* on intertidal benthic assemblages. April 2007. Thesis Defense. Moss Landing Marine Laboratories

Hughes, B. Effects of *Egregia menziesii* populations on rocky intertidal algal assemblages. November 2005. Oral presentation. Western Society of Naturalists Annual Meeting.

Hughes, B. Effects of *Egregia menziesii* populations on rocky intertidal algal assemblages. April 2005. Poster Presentation. Northwest Algal Symposium.

Kupfer, R., **B. Hughes**. Effects of light exposure on *Myxococcus xanthus* development. April 2002. Poster Presentation. Missouri Academy of Sciences Annual Meeting.

Hughes, B. Light induced inhibition of *Myxococcus xanthus* development. April 2002. Poster Presentation. Truman State University Undergraduate Research Symposium.

Hughes, B. Light induced inhibition of *Myxococcus xanthus* development. April 2001. Oral presentation. Truman State University Tri Beta meeting.

PUBLIC OUTREACH AND SYNERGISTIC ACTIVITIES

Hughes, B. Space invader's view of seagrass restoration: a success story from California. October 2018. Invited Presentation. SF Bay Ocean Conservation Meeting.

Hughes, B. New paradigms for coastal conservation in the 21st Century. September 2017. Invited Presentation. Friends and Anemones Society.

Hughes, B.B. Food webs, resilience, and functioning of coastal ecosystems. *Invited Seminar*. March 2018. Lions Club, Friday Harbor, WA.

Hughes, B.B. River Otters in a Land Without Rivers. May 2018. *Invited seminar*. University of Washington Friday Harbor Labs Open House.

Hughes, B. Top predator recovery presents new conservation challenges in the 21st century. September 2016. *Invited Presentation*. Monterey Bay Aquarium Volunteer Enrichment Series.

Hughes, B. Los efectos de fertilizantes a la ecología de Elkhorn Slough. March 2012. Presentación Oral en Español. Monterey Bay AgExpo.

Hughes, B., K. Wasson, J. Haskins. Spatial variability in eutrophication indicators across a tidal gradient in Elkhorn Slough, CA. December 2009. Oral Presentation. Monterey Bay National Marine Sanctuary/Water Quality Protection Program Quarterly Meeting.

Wasson, K., E. Van Dyke, J. Haskins, **B. Hughes**. Parsons Sill Project predictions for habitats, water quality, and biological communities. September 2009. Oral Presentation. Elkhorn Slough Tidal Wetland Project: Science Panel and Strategic Planning Team Meeting.

Hughes, B. Attack of the killer kelp. April 2006. Oral presentation. Moss Landing Marine Laboratories Open House. *Public Outreach Seminar.*

MENTORED GRADUATE# & UNDERGRADUATE* STUDENT PRESENTATIONS

#Lee, J., F. Micheli, **B.B. Hughes**, K.J. Kroeker. Are mutualistic interactions between seagrass and epiphyte grazer resilient to future ocean acidification? Western Society or Naturalists. Pasadena, CA. November 2017. Oral Presentation.

#Espinosa, S.M., Endris, C., Staedler, M.S., Fujii, J.A., **Hughes, B.B.**, Beheshti, K, Eby, R.G., Scoles, R.W., Bentall, G.B., Wasson, K., Tinker, M.T. Predictors of sea otter habitat use of salt marsh in Elkhorn Slough, CA. Western Society or Naturalists. Pasadena, CA. November 2017. Oral Presentation.

#Grimes, T.G., M.T. Tinker, **B.B. Hughes**, R.L. Lewison. Patterns of sea otter foraging activity and juvenile Dungeness crab habitat use. Western Society or Naturalists. Pasadena, CA. November 19, 2017. Poster Presentation.

#Lee, J., F. Micheli, **B.B. Hughes**, K.J. Kroeker, K.G. Peay. Effects of Ocean Acidification on surfgrass interaction with epiphytes, grazers, and opportunistic microbes. Western Society for Naturalists. Monterey, CA. November 12, 2016.

#Beheshti, K.M., **Hughes, B.B.**, Boyer, K, Greene, H.G., Endris, C. "Seagrass Restoration and the Trajectory of Enhanced Ecosystem Functioning." Western Society for Naturalists. Monterey, CA. November 12, 2016. 15-Minute Talk.

#Beheshti, K., **Hughes, B.**, Silliman, B., Angelini, C. "Crab Facilitation of Salt Marsh Loss: Abiotic Stressors Made Worse by Ecosystem Engineers." Western Society for Naturalists. Sacramento, CA. November 7, 2015.

#Beheshti, K., **Hughes, B.** et al. "How *Pachygrapsus crassipes* affect *Sarcocornia pacifica* loss in Elkhorn Slough, CA." 6th Annual Ecology and Evolutionary Biology Symposium. Long Marine Laboratory, Santa Cruz. May 8, 2015. 5-Minute Ignite Talk.

#Beheshti, K., **Hughes, B.** et al. "From *Sarcocornia* to *Zostera*: Just add water." 7th Annual Ecology and Evolutionary Biology Symposium. Long Marine Laboratory, Santa Cruz. April 29, 2016. 15-minute talk.

*Glanz, J., *B. Bulkin, **B. Hughes**. Trophic diversity influences growth strategies and competitive interactions in the eelgrass *Zostera marina*. Poster Presentation. Western Society of Naturalists November 2012, UC Santa Cruz Plant Research Symposium Feb 2013, Monterey Bay National Marine Sanctuary Currents Symposium April 2013.

*Abbey, S and **B. Hughes.** Impacts of anthropogenic nutrient loading on competitive interactions between eelgrass and ephemeral algae. April 2012. Poster Presentation. Monterey Bay National Marine Sanctuary Currents Symposium

*Van Parys, J., *M. Rodriguez, R. Preisler, J. Haskins, **B. Hughes**, and K. Wasson. October 2011. Water Quality at Elkhorn Slough and its impacts on Olympia Oysters (*Ostrea lurida*) and Staghorn Sculpins (*Leptocottus Armatus*). Poster Presentation SACNAS Annual Conference.

*Rodriguez, M., J. Haskins, **B. Hughes**, R. Preisler, K. Wasson. The relationship between water depth and hypoxia in managed estuarine wetlands: analysis and management recommendations. April 2011. Poster Presentation. Monterey Bay National Marine Sanctuary Currents Symposium.

*Johnson, L., **B. Hughes**. Variable effects of *Ulva* spp. on dissolved oxygen dynamics. April 2010. Poster Presentation. Monterey Bay National Marine Sanctuary Currents Symposium.

PROFESSIONAL SERVICE

Society for Conservation Biologists (Honorary Lifetime Membership)
Pacific Marine and Estuarine Fish Habitat Partnership (PMEP), Spatial Data Work Group (2015-present)
Session Co-Chair (Kerry Nichols, Tessa Hill, Kristy Kroeker), Coastal and Estuarine Research Federation, November 2015. "Multiple stressors in vegetated coastal ecosystems."
California Estuarine Research Society Student Representative (2011-2013)
Phycological Society of America (2003-2006), (2011-2015)
Elkhorn Slough Research Symposium, 2010 conference coordinator
Elkhorn Slough Tidal Wetland Program, Science Panel (2009-present)
California Estuarine Research Society (2009-present)
Coastal and Estuarine Research Federation (2009-present)
Northwest Algal Society (2005-2010)
Western Society of Naturalists (2004-present)
Monterey Bay National Marine Sanctuary, Water Quality Protection Program Committee (2009-2013)
Student Body Vice President, Moss Landing Marine Labs (2002-03).

MANUSCRIPT REVIEWER (SINCE 2011)

Nature Climate Change (1x), *Nature Communications* (1x), *Trends in Ecology and Evolution* (1x), *Conservation Letters* (1x), *Global Change Biology* (1x), *Frontiers in Ecology and the Environment* (1x) *BioScience* (1x), *Ecology* (3x), *Oecologia* (1x), *Journal of Ecology* (1x), *Ecosphere* (1x), *Estuaries and Coasts* (1x), *Marine Ecology Progress Series* (3x), *Journal of Experimental Marine Biology and Ecology* (1x), *Estuarine Coastal and Shelf Science* (1x), *Journal of Sea Research* (1x), *Environmental Biology of Fishes* (1x), *Marine Biology Research* (1x), *Elkhorn Slough Technical Report Series* (2x), *Pacific Marine and Estuarine Fish Habitat Partnership* (1x)

PROPOSAL REVIEWER (SINCE 2015)

NSF Biological Oceanography (1x), National Geographic Society (1x), Washington SeaGrant Panelist (1x), The Fram Centre (Norway) (2x), Earthwatch (1x), North Pacific Research Board (1x)

SKILLS

Field Skills: California boater certified, AAUS and NAUI Master and Scientific diver certified (200+ dives), CPR and First Aid certified, marine algal/invertebrate/vertebrate identification, ecological sampling techniques, acoustic tracking, ADCP, YSI, CTD, Water Quality.

Laboratory Skills: Sterile technique, Microscopy, Fluorometry, Spectrophotometry, Stable Isotopes, Cell culture, image analysis, media preparation.

Computer and Programming Skills: R, Systat, SPSS, SPSS Amos, JMP, Primer, ArcGIS, Canvas, Image J, Endnote, RiverSurveyor, View Argonaut, Microsoft Access/Word/Excel/Power Point, Adobe Photoshop, and website design and maintenance.

COMMUNITY & VOLUNTEER SERVICE

River Otter Day at Tomales High School. November 2019. *Invited Panelist*.
Friday Harbor Elementary School Volunteer Science Teacher, 2018.
Santa Cruz City School District, Volunteer Science and Music Teacher 2015-17
Monterey Bay Aquarium algal taxonomist, 2006-07
High School Teacher Enhancement Program, Moss Landing, CA 2005-06
Americorps volunteer, Kansas City, KS 2000
Special Olympics basketball league coordinator, Olathe, KS 1996-97
American Heart Association volunteer, Kansas City, MO 1994-97

KEY COLLABORATORS

Brian Silliman, Associate Professor, Duke University
Susan Williams, Professor, University of California Davis
M. Tim Tinker, Research Wildlife Biologist & Adjunct Professor, USGS and UC Santa Cruz
Kristy Kroeker, Assistant Professor, UC Santa Cruz
Ken Johnson, Senior Scientist, Monterey Bay Aquarium Research Institute
Kerstin Wasson, Research Coordinator, Elkhorn Slough National Estuarine Research Reserve
Christine Angelini, Assistant Professor, University of Florida
Mary Gleason, Associate Director of Marine Science, The Nature Conservancy
Mike Beck, Lead Marine Scientist, The Nature Conservancy
Aaron Carlisle, Post-doctoral Researcher, Stanford University
Margot Hessing-Lewis, Research Faculty, Hakai Institute
Ginny Eckert, University of Alaska Fairbanks
Lisa Needles, California Polytechnic University

PROFESSIONAL REFERENCES

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[redacted]

Curriculum Vitae

Aug 2018

David R Casper DVM
University of California, Santa Cruz
Long Marine Laboratory
100 Shaffer Rd., Santa Cruz, CA 95060
Office 831.459.3135 Fax 831.459.3383
Email: dcasper@ucsc.edu

Education

Medical DVM, University of Illinois, Champaign Urbana, IL 1973, Phi Zeta Honor Society
Bachelor of Veterinary Medicine, University of Illinois, Champaign Urbana, IL 1971, Edmund J. James Scholar

Current Position

Director of Veterinary Services at UCSC
Director of BioMed Vivarium at UCSC
Director LML Marine Mammal Stranding network
Attending Veterinarian, Long Marine Laboratory
Attending Veterinarian Moss Landing Marine Lab
Contract Veterinarian Monterey Bay Aquarium

Professional Affiliations

International Association of Aquatic Animal Medicine
Society for Marine Mammalogy
American Association of Zoos and Aquaria
American Veterinary Medical Association
California Veterinary Medical Association

Professional Experience

2000-present	Sea Otter surgical implantation of transmitters, central California coast
2000-present	Contract Veterinarian Monterey Bay Aquarium
1997-present	Director LML Marine Mammal Stranding network
2000-2003	"Tagging of Pacific Pelagics" project (TOPP), sampling and tagging free-ranging sea lions
1995-99	White shark tagging and tracking program, Año Nuevo Island, CA
1996-99	Leopard shark ecology, Elkhorn Slough Research Reserve, Elkhorn, CA
1993	NMFS Dolphin live capture, Beaufort, NC
1992	White sided dolphin research project, UCSC
1992	NMFS Dolphin live capture, Matagorda Bay, TX
1989-91	Director of Research and Veterinary Services, John G. Shedd Aquarium, Chicago, Ill
1989	Dolphin Biology Research Associates live capture, Sarasota, FL
1989	White sided dolphin research project, UCSC
1988	Dolphin Biology Research Associates live capture, Sarasota, FL

Research and Publications

Coccidioidomycosis and Other Systemic Mycoses of Marine Mammals Stranding Along The Central California, USA Coast: 1998-2012
By: Huckabone, Sara E.; Gulland, Frances M. D.; Johnson, Suzanne M.; et al.
JOURNAL OF WILDLIFE DISEASES Volume: 51 Issue: 2 Pages: 295-308 Published: APR 2015

Recovery rates of bottlenose dolphin (Tursiops truncatus) carcasses estimated from stranding and survival rate data
JAMES V. CARRETTA,1 KERRI DANIL, SUSAN J. CHIVERS et al.
Marine Mammal Science
Volume 32, Issue 1, Article first published online: 4 SEP 2015Biochemical and hormonal changes during acute fasting and re-feeding in bottlenose dolphins (Tursiops truncatus)
By: Ortiz, Rudy M.; Long, Brett; Casper, Dave; et al.
MARINE MAMMAL SCIENCE Volume: 26 Issue: 2 Pages: 409-419 Published: APR 2010

An Unusual Mortality Event of Harbor Porpoises (Phocoena phocoena) Off Central California: Increase in Blunt Trauma Rather Than an Epizootic
By: Wilkin, Sarah M.; Cordaro, Joe; Gulland, Frances M. D.; et al.
AQUATIC MAMMALS Volume: 38 Issue: 3 Pages: 301-310 Published: 2012

Isotopic incorporation rates for shark tissues from a long-term captive feeding study
By: Kim, Sora Lee; del Rio, Carlos Martinez; Casper, Dave; et al.
JOURNAL OF EXPERIMENTAL BIOLOGY Volume: 215 Issue: 14 Pages: 2495-2500 Published: JUL 2012

Carbon and nitrogen discrimination factors for elasmobranch soft tissues based on a long-term controlled feeding study
By: Kim, Sora Lee; Casper, Dave R.; Galvan-Magana, Felipe; et al.
ENVIRONMENTAL BIOLOGY OF FISHES Volume: 95 Issue: 1 Special Issue: SI Pages: 37-52 Published: SEP 2012

Meningoencephalitis Associated With Carnobacterium maltaromaticum-Like Bacteria in Stranded Juvenile Salmon Sharks (Lamna ditropis)
Schaffer, P. A.; Lifland, B.; Van Sommeran, S.; et al.
VETERINARY PATHOLOGY Volume: 50 Issue: 3 Pages: 412-417 Published: MAY 2013

Biochemical and hormonal changes during acute fasting and re-feeding in bottlenose dolphins (Tursiops truncatus)
By: Ortiz, Rudy M.; Long, Brett; Casper, Dave; et al.
MARINE MAMMAL SCIENCE Volume: 26 Issue: 2 Pages: 409-419 Published: APR 2010

Running, swimming and diving modifies neuroprotecting globins in the mammalian brain
Williams, TM (Williams, Terrie M.)[1] ; Zavanelli, M (Zavanelli, Mary)[2] ; Miller, MA (Miller, Melissa A.)[5,4] ; Goldbeck, RA (Goldbeck, Robert A.)[3] ; Morledge, M (Morledge, Michael)[2] ; Casper, D (Casper, Dave)[1] ; Pabst, DA (Pabst, D. Ann)[6] ; McLellan, W (McLellan, William)[6] ; Cantin, LP (Cantin, Lucas P.)[3] ; Kliger, DS (Kliger, David S.)[3]
PROCEEDINGS OF THE ROYAL SOCIETY B-BIOLOGICAL SCIENCES
Volume: 275 Issue: 1636 Pages: 751-758
Published: APR 7 2008

Seasonal Variability in Otariid Energetics: Implications for the effects of predators on localized prey resources, Terrie M. Williams, M. Rutishauser, B. Long, T. Fink, J. Gafney, H. Mostman-Liwanag, D. Casper , Physiological and Biochemical Zoology, May:80(4)

Absence of neurotoxic effects in leopard sharks, Triakis semifasciata, following domoic acid exposure. Schaffer P, Reeves C, Casper DR, Davis CR. Toxicon. 2006 Jun 1;47(7):747-52. Epub 2006 Mar 29
Incidence of Temporomandibular Arthritis in California Sea Lions (*Zalophus californianus*).
David Aurioles-Gamboa, Claudia Diaz-Guzman, Burney J. Le Bœuf, David Casper (in preparation)

Characterization and Clinical Manifestations of Arcanobacterium Phocae Infections in Marine Mammals Stranded Along the Central California Coast

Shawn Johnson, Spencer Jang, Frances Gulland, Melissa Miller, Dave Casper, Judy Lawrence, Juliet Herrera
J Wildl Dis. 2003 Jan;39(1):136-44.

CANINE DISTEMPER VACCINATION IS A SAFE AND USEFUL PREVENTIVE PROCEDURE FOR SOUTHERN SEA OTTERS (ENHYDRA LUTRA NEREIS)
By: Jessup, David A.; Murray, Michael J.; Casper, David R.; et al.
JOURNAL OF ZOO AND WILDLIFE MEDICINE Volume: 40 Issue: 4 Pages: 705-710 Published: DEC 2009

Bottlenose Dolphins as Marine Ecosystem Sentinels: Developing a Health Monitoring System
Randall S. Wells, Howard L. Rhinehart, Larry J. Hansen, Jay C. Sweeney, Forrest I. Townsend, Rae Stone, David Casper, Michael D. Scott, Aleta A. Hohn, and Teri K. Rowles
EcoHealth 1, 246–254, 2004 Special issue of "Ecosystem Health" dedicated to symposium in October 2000 in New York

In Vitro Lymphocyte Responses Of Bottlenose Dolphins (Tursiops Truncatus): Mitogen Induced Proliferation
Garet P. Lahvis, Randall S. Wells, David Casper , and Charles S. Via
Marine Environmental Research 34 (1992) 000-000, Elservier Science Publishing, London, Eng.

Bottlenose Health Assessment: Field Report On Sampling Near Beaufort, North Carolina, During July, 1995
NOAA Technical Memorandum NMFS-SEFSC-382

First Record of A Live-Stranded Pan-Tropical Spotted Dolphin Stenella-Attenuata-graffmani in Central California USA.
Worthy, G; Casper, D; Rhinehart, H; Moser, M.
Marine Mammal Science, v.9, n.3, (1993): 316-319.

WEBSITES

http://www.mmapl.ucsc.edu/
Marine Mammal Pathology Library
The Marine Mammal Anatomy and Pathology Library (MMAPL) is a resource for high quality images, information, and training tools describing normal anatomy and species specific pathologies of marine mammals.
MMAPL was developed for the marine mammal stranding community, the larger marine mammal research community, veterinarians, pathologists, and educators.
17 intuitional partners contributed to this project.
Collaboration was key to the development of this unique resource and continues to be critical as MMAPL continues to grow and evolve.

REPORTS

Blood Profiles Of Free-Ranging Bottlenose Dolphins From The Central West Coast Of Florida: Report submitted to the Southeast Fisheries Center of the National Marine Fisheries Service
H. Rhinehart, R. S. Wells, F.. Townsend, J. C. Sweeney, D. R. Casper

Health Assessment Of A Population Of Bottlenose Dolphins, Tursiops Truncatus, At Matagorda Bay, Texas, Following A Mortality Event: Report submitted to the Southeast Fisheries Center of the National Marine Fisheries Service
J. C. Sweeney, D. R. Casper F.. Townsend, L. R Stone, and Larry Hansen

A Model for Assessing the Relative Health of Dolphin Populations: Report submitted to the Southeast Fisheries Center of the National Marine Fisheries Service
J. C. Sweeney, D. R. Casper, J. S. Reif, F. Townsend, R. S. Wells, and Larry Hansen

An independent investigation of the Gulfarium's animal care programs and facility. Report submitted to the Gulfarium, Fort Walton Beach, Florida.
D. Casper, K. Ramirez

POSTER PRESENTATIONS

Sea Lion Anatomy and Patholgy: An Innovative New Website for Sharing Information between Stranding Network Participants:
David Casper, Melissa Miller, Sentiel (Butch) Rommel PhD, Dave Jessup, Leslie A. Dierauf, Frances Gulland PhD, MRCVS, Marty Haulena, Linda Lowenstine, Katie Colegrove, Tanja S. Zabka, Kathy Burek, Judy St. Leger, Beth Buckles, Jim Harvey PhD

Menigoencephalitis In Juvenile Salmon Sharks Associated With Carnobacterium Sp.:
C.R. Davis, B.D. Lifland, P.A. Schaffer, D.R. Casper, and S. Van Sommeran.

Monitoring Heat Flow In Dolphins: A New Method For Assessing Optimal Water Temperature
Casper. D., Rhinehart, H., Costa, D.

Initial Care And Stabilization Of A Stranded Pygmy Sperm Whale, Kogia Breviceps: A Team Approach
Rhinehart, H., Casper, D., Worthy, G.A.J., and Wells, M.

Adaptation of Human Immune Assays to Characterize Lymphocyte Function of the Bottlenose Dolphin
Garet P. Lahvis, Randall S. Wells, David Casper, Charles S. Via

BIOGRAPHICAL SKETCH

Provide the following information for the Senior/key personnel and other significant contributors.
Follow this format for each person. **DO NOT EXCEED FIVE PAGES.**

NAME: Christine Kreuder Johnson

eRA COMMONS USER NAME: CKREUDER-JOHNSON

POSITION TITLE: Professor of Epidemiology and Ecosystem Health

EDUCATION/TRAINING

INSTITUTION AND LOCATION	DEGREE	Completion Date	FIELD OF STUDY
University of California, Davis, California	PhD	00/2003	Epidemiology
University of California, Davis, California	MPVM	00/2000	Wildlife Epidemiology
University of Pennsylvania, Philadelphia, PA	VMD	05/1994	Veterinary Medicine
Duke University, Durham, North Carolina	BS	00/1990	Zoology/Political Science

A. Personal Statement

As Professor of Epidemiology, I am committed to advancing infectious disease investigations at the interface of animal, human, and environmental health through applied research that can inform public policy related to disease prevention and outbreak preparedness. Recent primary research activities investigate the environmental drivers influencing the ecology of infectious diseases emerging at the animal-human interface and patterns in transmission of zoonotic viruses, often in the international setting. For USAID's Emerging Pandemic Threats PREDICT program, I lead the optimization of surveillance activities in 30 resource-limited countries where we work in partnership with agricultural, wildlife, and public health sectors to inform on public health risk associated with zoonotic pathogens. This work has sought to establish an international network of scientists engaged in rigorous data collection to characterize risk of zoonotic disease transmission. For PREDICT, I have directed large-scale international grant activities in partnership with local clinics and hospitals to investigate fevers of unknown origin in patients, as well engage high-risk communities to concurrently sample people, livestock, and wildlife to detect viral sharing. Research has sought to strengthen disease detection capabilities for high priority zoonoses and understand the human dimensions of spillover, providing insight for behavior changes needed to mitigate risk and prevent epidemics. My most rewarding professional experiences often involve providing epidemiologic support to federal and state agencies to inform policy, including the California Department of Fish and Wildlife, US Fish and Wildlife Service, National Oceanic and Atmospheric Administration, the U.S. Agency for International Development, and the Department of Defense. To further advance epidemiologic solutions to complex problems at the interface of animal, human, and environmental health, I established the EpiCenter for Disease Dynamics, which uses data-driven approaches to model the dynamics of zoonotic pathogen spillover and spread.

As faculty at the university, I have developed new curriculum for health professionals and graduate students in one health, ecosystem health, and epidemiology. I lead a well-rounded graduate training program in wildlife epidemiology and disease dynamics with primary mentorship of over 20 graduate students and 11 post-doctoral scholars obtaining advanced training in epidemiology and disease ecology. With my supervision, trainees take an active role in optimizing study design, implementing field and laboratory activities, and undertaking advanced analytical challenges in their research. Trainees benefit from a collegial environment that supports diversity and encourages applied research activities in partnership with state, federal, and international agencies. All doctoral graduates have gone on to prominent agency leadership positions and faculty positions at top universities.

B. Positions and Honors

Positions

1995 – 1996 Associate Equine Veterinarian, Caldor Race Course, Griffith Equine Practice, Miramar, FL
1996 – 1999 Veterinarian/ Director of Research, Clinic for the Rehabilitation of Wildlife, Sanibel, FL
1998 – 2000 Associate Equine Veterinarian, Peninsula Equine, Palo Alto, CA
1999 – 2003 Post Graduate Researcher, Wildlife Health Center, School of Veterinary Medicine, University of California, Davis, CA
2003 – 2006 Wildlife Veterinarian, Wildlife Health Center, School of Veterinary Medicine, University of California, Davis, CA
2006 – present Professor of Epidemiology, Department of Medicine and Epidemiology, School of Veterinary Medicine, University of California, Davis, CA
2015 – present Director, EpiCenter for Disease Dynamics, Associate Director, One Health Institute, University of California, Davis, CA

Honors

2000 Peter J. Shields Fellowship Award
2001 California Coastal Environmental Quality Initiative Fellowship Award
2002 Morris Animal Foundation Fellowship Award
2008 Council Wildlife Disease Association
2012 Distinguished Faculty Teaching Award
2016 Chair of the Faculty, School of Veterinary Medicine
2017 UC Davis Academic Senate Distinguished Scholarly Public Service Award

C. Contributions to Science

1. Discovery of Emerging Infectious Diseases at the Animal-Human Interface

Interest in emerging infectious disease was sparked by the need for veterinarians with wildlife health expertise to inform on zoonotic diseases emerging from wild animal reservoirs. Early research activities began with evaluating risk of influenza transmission at high-risk human-animal interfaces in California, and my work has since expanded to large scale surveillance activities in over 35 countries in Asia, Africa, and Latin America to meet global health priorities. My work intersects animal and human health, with investigations typically focused on human populations with high levels of contact with wildlife, and wildlife populations with high levels of contact with humans. By design, my research activities seek to integrate multi-disciplinary expertise and next generation techniques in laboratory detection, social and behavioral sciences, and disease ecology. As co-Principal investigator for the Emerging Pandemic Threats PREDICT project for the past 10 years of project implementation, I have contributed to the design and implementation of the largest effort to date to investigate zoonotic virus spillover risk on a global scale. PREDICT works in close partnership with host country governments to strengthen capacity for detection of emerging infectious disease locally in resource-limited regions where advanced detection capabilities are needed most. Our work has enabled One Health partnerships in field surveillance, laboratory detection and pathogen discovery, and platforms for disease reporting that are closely coordinated with Ministries of Health, Ministries of Livestock, and Ministries of Wildlife.

a) Siembieda J, Johnson C, Boyce W, Sandrock C, Cardona C. Risk for avian influenza virus exposure at the human-wildlife interface. Emerging Infect Diseases, 14(7): 1151-3, 2008.
b) PREDICT Consortium. Reducing Pandemic Risk, Promoting Global Health. One Health Institute, University of California, Davis, December 2014. (http://www.vetmed.ucdavis.edu/ohi/local_resources/pdfs/predict-final-report.pdf)
c) Smiley Evans T, Tutaryebwa, Gilard KV, Barry PA , Marzi A, Eberhart M, Ssebide B, Cranfield MR, Mugisha O, Mugisha E, Kellermann S, Mazet JAK, Johnson CK . Suspected exposure to filoviruses among people contacting wildlife in Southwestern Uganda, The Journal of Infectious Diseases, jiy251. https://doi.org/10.1093/infdis/jiy251. 2018.
d) Goldstein T, Anthony SJ, Gbakima A, Bird BH, Bangura J, Tremeau-Bravard S, Belaganahalli MN, Wells H, Dhanota JK, Liang E, Grodus M, Jangra RX, Dejesus VA, Lasso G, Smith BR, Jambai A, Kamara BO, Kamara S, Bangura W, Monagin C, Shapira S, Johnson CK, Saylors K, Rubin EM, Chandran K, Lipkin WI,

Mazet JAK. The discovery of Bombali virus adds further support for bats as hosts of ebolaviruses. Nature Microbiology doi.org/10.1038/s41564-018-0227-2. 2018.

2. *Advancing Surveillance for Emerging Epidemic and Pandemic Threats*
My work has pioneered new approaches to surveillance targeting wildlife hosts for emerging infectious diseases. As Senior Personnel for Biological and Ecological Surveillance, for USAID's Emerging Pandemic Threats PREDICT project, I have led surveillance activities to detect viral threats in animals and humans in 30 countries. Field activities were designed to concurrently sample people, domestic animals, and wildlife, to identify viral sharing between species and characterize the evolutionary mechanisms and epidemiologic circumstances involved in disease transmission. Efforts to date have optimized best practices in surveillance design to detect cross-species disease transmission and identify reservoir hosts for emerging threats (such as ebolaviruses in West Africa). Faced with logistical hurdles in sampling difficult-to-handle wildlife species, we designed new non-invasive sampling techniques, evaluated and optimized these techniques in captive species for detection of a range of viral pathogens, and trained teams in Africa and Asia in implementation. We have designed outbreak investigations at the request of country governments to evaluate animal involvement in outbreaks in the public health sector and assist in outbreak response. We established new approaches to characterizing epidemics in animal reservoirs and suspected spillover hosts and have used these same techniques to characterize the epidemiology of outbreaks in terrestrial species and marine mammals involved in unusual morbidity and mortality events.

a) Smiley Evans, T, PA Barry, KV Gilardi, T Goldstein, JD Deere, J Fike, J Yee, BJ Ssebide, D Karmacharya, MR Cranfield, D Wolking, B Smith, J AK Mazet, and CK Johnson. Optimization of a novel non-invasive oral sampling technique for zoonotic pathogen surveillance in nonhuman primates. PLOS Neglected Tropical Diseases, 9(6), 2015.
b) Smiley Evan T, Gilardi KV, Barry PA, Ssebide BJ, Kinani JF, Nizeyimana F, Noheri JB, Byarugaba DK, Mudakikwa A, Cranfiedl MR, Mazet JA, Johnson CK. Detection of viruses using discarded plants from wild mountain gorillas and golden monkeys. American Journal of Primatology, 78(11): 1222-1234. 2016.
c) Siembieda JL, Hall AJ, Gulland FMD, Rowles T, Garron M, Matassa K, Rotstein DS, Gonzalez S, Northeast Region Marine Mammal Stranding Network, Johnson CK. Epidemiology of a phocine distemper virus outbreak along the North Atlantic Coast of the United States. Aquatic Mammals, 43(3): 254-263. 2017.
d) Kelly TK, Karesh WB, Johnson CK, Gilardi KV, Anthony S, Goldstein T, Olson S, Machalaba C, Mazet JK. One Health proof of concept: Bringing a transdisciplinary approach to surveillance for zoonotic viruses at the human-wild animal interface. Prev Vet Med, 137: 112-8. 2017.

3. *Epidemiological Modeling of Mechanisms Involved in Virus Spillover and Spread*
At the EpiCenter for Disease Dynamics, I lead a team of talented epidemiologists and modelers in the development of advanced computational methods to estimate the risk of spillover from wild animal hosts, highlight the transmission mechanisms and animal-to-human interfaces common to disease spillover, and estimate the magnitude of subsequent disease spread within at-risk human populations. To date, scientific outcomes have been tailored to assist the US Department of Defense in understanding outbreak risks and preparing for a range of outbreak responses and we have completed two contracts contributing data and applications to the Defense Threat Reduction Agency's Biosurveillance Ecosystem in the Chemical and Biological Technologies Department. Current initiatives integrate viral findings from PREDICT and data from all zoonotic viruses recognized to date to characterize species propensities to serve as a source of zoonotic spillover and enable risk prediction.

a) Johnson CK, PL Hitchens, T Smiley Evans, T Goldstein, K Thomas, A Clements, DO Joly, ND Wolfe, P Daszak, WB Karesh, JK Mazet. Spillover and pandemic properties of zoonotic viruses with high host plasticity. Scientific Reports. 5:14830. 2015.
b) Anthony, S, A Islam, CK Johnson, I Navarrete-Macias, E Liang, K Jain, P Hitchens, Xiaoyu Che, A Soloyvov, A Hicks, R Ojeda-Flores, C Zambrana-Torrelio, W Ulrich, M Rostal, A Petrosov, J Garcia, N Haider, N Wolfe, T Goldstein, S Morse, M Rahman, J Epstein, J Mazet, P Daszak, and W Lipkin. Non-random patterns in viral diversity. Nature Communications, 6: 8147. 2015.
c) Anthony SJ, Johnson CK, Greig DJ, Kramer S, Che X, Wells H, Hicks AL, Joly DO, Wolfe ND, Daszak P,

Karesh W, Lipkin WI, Morse SS, PREDICT Consortium, Mazet JAK, Goldstein T. Global patterns in coronavirus diversity. Virus Evol, 3(1): vex012. 2017.

d) Pandit P, Doyle M, Smart K, Young C, Drape G, Johnson CK. Predicting wildlife reservoirs and global vulnerability to zoonotic Flaviviruses. Nature Communications. 9:5424 2018.

4. Understanding Ecosystem-level Processes Impacting Wildlife Health

Research activities related to wildlife population health have sought to uncover ecosystem-level processes underlying patterns in disease at the population level. Examples below highlight multi-decadal population-wide studies conducted to understand processes promoting disease in sea otters, mountain lions, California condors, and other at-risk species. For these studies, new trans-disciplinary approaches were developed to integrate in-depth ecological data and advanced pathogen detection data to evaluate the influence of animal movements, behaviors, and diet choices on health and survivorship at the population scale. I have also served as primary mentor to graduate students training in epidemiology and disease ecology involved in this work.

a) Johnson CK, Tinker MT, Estes JA, Conrad PA, Staedler M, Miller MA, Jessup DA, Mazet JA. Prey choice and habitat use drive sea otter pathogen exposure in a resource-limited coastal system. Proceedings of the National Academy of Sciences, 106(7): 2242–7, 2009.

b) Vickers TW, Sanchez JN, Johnson CK, Morrison SA, Botta R, Smith T, Cohen BS, Huber PR, Ernest HB, Boyce WM. Survival and mortality of pumas (*Puma concolor*) in a fragmented, urbanizing landscape. PLoS One, 10(7): e0131490, 2015.

c) Vilchis, LI, Johnson, CK, Evenson, JR, Pearson, SF, Barry, KL, Davidson, P, Raphael, MG, Gaydos, JK. Assessing ecological correlates of marine bird declines to inform marine conservation. Conservation Biology, 29(1): 154-63, 2015.

d) Burgess T, Tinker T, Miller M, Bodkin J, Murray M, Saarinen J, Nichol L, Larson S, Conrad P, Johnson CK. Defining the risk landscape in the context of pathogen pollution: Toxoplasma gondii in sea otters along the Pacific Rim. R Soc Open Sci, 5(171178). 2018

5. *Informing Conservation and Wildlife Health Policy*

Activities in the area of wildlife conservation exemplify a strong commitment to informing state and federal agencies on disease risks to threatened wildlife species and serving pressing research needs at the boundaries of science and policy. As Principal Investigator, I have secured both state and federal wildlife agency funding for large-scale studies that can directly inform conservation and management of endangered wildlife projects. For these projects, I have ensured that research deliverables are tightly aligned with top agency priorities and involve multi-disciplinary teams with a diversity of expertise and perspectives as well as ongoing engagement of key stakeholders. Our work on condors was under intense public scrutiny because of the political implications associated with ammunition regulations, and we established a strong commitment to transparent scientific activities and data sharing. We found policy was well informed by consensus statements involving leading public health and toxicology scientists. These research activities have had direct implications for science-based policy and resulting legislation needed to mitigate pathogen pollution in sea otters and exposure to lead-based ammunition in California condors.

a) Johnson, CK, Kelly, TR, Rideout, BA. Lead in ammunition: a persistent threat to health and conservation. EcoHealth, 10(4): 455-64, 2013.

b) Kelly, TR, Grantham, J, George, D, Welch, A, Brandt, J, Burnett, LJ, Sorenson, KJ, Johnson, M, Poppenga, R, Moen, D, Rasico, J, Rivers, JW, Battistone, C, Johnson, CK. Spatiotemporal patterns and risk factors for lead exposure in endangered California condors during 15 years of reintroduction. Conservation Biology, 28(6): 1721-30, 2014.

c) Kelly, Terra R., et al. "Causes of mortality and unintentional poisoning in predatory and scavenging birds in California." *Veterinary Record Open* 1.1 (2014): e000028.

d) Kelly TR, Rideout BA, Grantham J, Brandt J, Burnett LJ, Sorenson KJ, George D, Welch A, Moen D, Rasico J, Johnson M, Battistone C, Johnson CK . Two decades of cumulative impacts to survivorship of endangered California condors in California. Biol Conserv, 191: 391-9. 2015.

Link to a complete list of publications https://scholar.google.com/citations?user=SCy6lAcAAAAJ&hl=en

D. Additional Information: Research Support (within the last 3 years)

Title: Emerging Pandemic Threats (EPT-2) Program PREDICT-2
Agency: US Agency for International Development
Scope: Investigation of viral threats at high-risk animal-human interfaces to strengthen pandemic preparedness in 30 resource limited countries at risk for emerging infectious diseases.
Date(s): 10/01/2014 – 09/30/2019

PI/Co-PI: Co-Principal Investigator, Jonna Mazet (PI)
Title: Modeling Health Capacity & Governance for Zoonotic Disease Outbreak Prediction
Agency: Department of Defense, Defense Threat Reduction Agency (subawardee to ENSCO)
Scope: Develop models to forecast outbreak size and risk of outbreak spread for select agents, accounting for variation in health capacity and governance of a given country/region
Date(s): 12/01/2015-11/30/2017
PI/Co-PI: Principal Investigator

Title: Data-Driven Framework for Zoonotic Disease Prediction
Agency: Department of Defense, Defense Threat Reduction Agency (subawardee to ENSCO)
Scope: Develop disease prediction models with automated access to datasets, data normalization, and data visualization of geospatial risk for select zoonotic viruses.
Date(s): 10/01/2014 – 09/30/2017
PI/Co-PI: Principal Investigator

Title: Enhanced Passive Surveillance for Wildlife Diseases in California
Agency: California Department of Fish and Wildlife
Scope: Establishes a network of wildlife responders and data entry system that detects unusual morbidity and mortality events and automatically characterizes potential outbreaks throughout the state of California, with built in reporting to the state wildlife agencies.
Date(s): 07/01/2014-06/30/2017
PI/Co-PI: Co-Principal Investigator, Terra Kelly (PI)

Title: EcoHealth Net 2.0: A One Health Approach to Disease Ecology Research & Education
Agency: National Science Foundation
Scope: A research collaboration grant that advances research in disease ecology by connecting trainees with research and mentoring opportunities in epidemiology, disease modeling, and emerging infectious disease research.
Date(s): 08/25/2016-08/31/2021
PI/Co-PI: Co-Principal Investigator, Jonathan Epstein (PI)

Title: Prediction of Spillover Potential and Interventional En Masse Animal Vaccination to Prevent Emerging Pathogen Threats in Current and Future Zones of US Military Operation
Agency: Defense Advanced Research Projects Agency
Amount: [redacted]
Date(s): 10/1/2018 – 3/31/2022
PI/Co-PI: Peter Barry (lead), Brian Bird (Co-PI), Michael Jarvis (Co-PI), Scott Nuismer (Co-PI)
Role: Co-Investigator, Subject Matter Expert

Title: Exploration of novel biomarkers for repeated domoic acid exposure and associated chronic health impacts in at-risk southern sea otters (*Enhydra lutris nereis*)
Agency: Oiled Wildlife Care Network
Amount: [redacted]
Date(s): 7/1/2018 – 6/31/2019
PI/Co-PI: Principal Investigator

Bio-Bibliography
University of California, Santa Cruz, CA
DANIEL PAUL COSTA

EMPLOYMENT

2016-	**SSC IMBER**-Integrated Marine Biogeochemistry & Ecosystem Research
2011	Distinguished Professor of Ecology and Evolutionary Biology Step IX above scale
2011-2017	**SOOS**-Southern Ocean Observing System Science Steering Committee
2010-2014	Member Central and Northern California Ocean Observing System, CENCOOS Council
2009-2013	Member **ORRAP-**Ocean Resources and Research Advisory Panel
2009-present	Science Steering Committee **ICED**- Integrated Climate & Ecosystem Dynamics
2009-2017	Science Steering Committee **CLIOTOP**- Climate Change & Top Predators
2008-2013	Ida Benson Endowed chair of Ocean Health
2007	Professor of Ecology and Evolutionary Biology Step IX
2005	Professor of Ecology and Evolutionary Biology Step VII
2002	Professor of Ecology and Evolutionary Biology Step VI
2001 & 2002	Chief Scientist Southern Ocean **GLOBEC** Process Cruise. July-August
2002-2006	Secretary Society of Marine Mammalogy
2000-2011	Steering Committee Southern Ocean **GLOBEC**
1999	Zoologist in Residence, University of Tasmania, Hobart, Australia
1995-97	Associate Director, Institute of Marine Sciences
1994-97	Associate Chair of Biology
1993-	Professor of Biology
1991-93	Scientific Officer, Physiology and Marine Mammal Biology Office of Naval Research, Arlington, Virginia Associate Professor of Biology
1988-90	Associate Adjunct Professor of Biology and Marine Science
1989	June through September, U.S. Navy - ASEE Senior Faculty Fellow, Naval Oceans Systems Center, Kaneohe, Hawaii
1986-88	Associate Research Biologist, University of California, Santa Cruz
1983-86	Assistant Research Biologist, University of California, Santa Cruz
1987	November, Visiting Scientist, British Antarctic Survey, Cambridge, England July through September, U.S. Navy - ASEE Senior Faculty Fellow, Naval Oceans Systems Center, Kaneohe, Hawaii April through June, Visiting Scientist, Abteilung Wickler, Max-Planck Institut für Verhaltensphysiologie, Seewiesen, West Germany.
1985	August and September, Visiting Scientist, British Antarctic Survey, Cambridge England
1979-82	National Institutes of Health Postdoctoral Fellowship, Physiological Research Laboratory, Scripps Institution Oceanography
1978-82	Postdoctoral Research Physiologist Scripps Institution Oceanography
1977-78	Staff Research Associate, Scripps Institution Oceanography
1977	Teaching Assistant, Biology, University of California, Santa Cruz
1976	Research Assistant, University of California, Santa Cruz
1975	Teaching Assistant, Biology, University of California, Santa Cruz
1974	Laboratory Assistant, Laboratory of Nuclear Medicine and Radiation Biology, University of California, Los Angeles

EDUCATION

1978-1982	Scripps Institution of Oceanography, Postdoctoral Physiologist
1978	University of California, Santa Cruz, Ph.D. (Biology)
1974	University of California, Los Angeles, B.A. (Zoology, Honors) Cum Laude

MEMBERSHIPS IN HONORARY SOCIETIES

Fellow, California Academy of Sciences
American Geophysical Union
American Society of Limnology & Oceanography
American Physiological Society
American Society of Mammalogists
Society of Integrative and Comparative Biology
Ecological Society of America
Society of Marine Mammalogy
Acoustical Society of America
Sigma Xi

HONORS, AWARDS & GRANTS

2018 Developing Metrics of Animal Condition and their linkage to Vital Rates: Further Development of the PCoD Model: Office of Naval Research, Aug 1, 2018 July 31, 2021 [redacted]

Joint Industry Programme on E&P Sound and Marine Life - Phase III, Towards a Risk Assessment Framework/Protocol for Implementing the Data-Driven Population Consequences of (Acoustic) Disturbance (PCAD/PCoD) Model/Approach. 7/1/2018 – 12/31/2020. $[redacted]

2017 'PCoD+: Developing widely-applicable models of the population consequences. Sub-award St Andrews University, Prime Office of Naval Research 1/1/17 -12/31/20, $[redacted]

Collaborative Research: Foraging Ecology and Physiology of the Leopard Seal. NSF Polar Programs, October 1 2017- Sept 31 2020. [redacted]

Collaborative Research: At-sea experimental disturbances to characterize physiological plasticity in diving northern elephant seals, MLML prime NSF Integrative Biology August 15, 2017 to July 31, 2021. [redacted]

Investigating the foraging behavior of a large predator, the northern elephant, UC Mexus, 1/1/17 - 12/31/18 [redacted]

2016 Development of the PCAD Model to Assess Biological Significance of Acoustic Disturbance. Office of Naval Research Jan – Dec 2018, [redacted]

2015 Unraveling the Genomic and Molecular Basis of the Dive Response, Massachusetts General Hospital, Office of Polar Programs NSF 7/15/15-6/30/18. [redacted]

Marine energy harvesting for remote system operational expansion. sub-award from Northern Arizona University, funding agency NSF Ocean Technology and Interdisciplinary Coordination (OTIC) 9/16/15-8/31/18, [redacted]

2014 A Bioenergetic Model to Estimate the Population Consequences of Disturbance. Marine Life Joint Industry Program, Sept 2014 –June 2018. [redacted]

2013 Retrospective Analysis of Antarctic Tracking Data (RAATD): International Crabeater and Weddell Seal Tracking Data Sets. 3/1/2013-2/28/2015 [redacted]. Office of Polar Programs National Science Foundation.

2012 Application of the PCAD Model to the California Gray Whale, Integration of Existing Data and Towards a Quantitative Assessment of Biological Significance of Acoustic Disturbance. Joint Award Shell America Upstream and ExxonMobil Research Company. Nov 1 2012-Sept 31 2014. [redacted]

Development of the PCAD Model to Assess Biological Significance of Acoustic Disturbance. October 1 2012- September 31 2015. Office of Naval Research. [redacted]

2010 Environmental perturbations, behavioral change, and population response in a long-term northern elephant seal study. 1/1/2010-12/31/2012, [redacted]. Office of Naval Research.

Phase III Tagging of Pacific Pelagics. Alfred P. Sloan Foundation, 1/1/2010-12/31-2010, [redacted]

2009-2013 ORRAP Ocean Research Advisory Panel, Appointed by the Secretary of the Navy

Collaborative Research: Weddell seals as autonomous sensors of the winter oceanography of the Ross Sea, 7/1/2009 -6/30/2013,[redacted]. Office of Polar Programs, National Science Foundation.

2008-2013 Ida Benson Endowed Chair of Ocean Health

Eminent Scholars Lecture, University of South Florida February 2008.

Use of electronic tag data and associated analytical tools to identify and predict habitat utilization of marine mammals,[redacted]. 8/2008-8/2011. Office of Naval Research

Relating Behavior and Life Functions to Populations Level Effects in Marine Mammals: An empirical and modeling effort to develop the PCAD model. 3/2008-2/2010. [redacted]. Marine Life Joint Industry Program.

2007 TOPP Phase III: Pilot Projects Involving Birds and Marine Mammals 2007-2009. [redacted] 5/2007-4/2009 Packard Foundation.

Mapping Hot Spots in California Current and Advancing Archival Tag Technology. [redacted] 12/2007- 6/2009. Gordon and Betty Moore Foundation.

Tagging of Pacific Pelagics: Identifying and Conserving Pacific Hot Spots in the California Current. 4/2007-3/2010. Alfred P Sloan Foundation

2006 Collaborative Research: U.S. SO GLOBEC Synthesis and Modeling - Habitat Utilization and Predator-Prey interaction in Western Antarctic Peninsula. NSF Polar Programs [redacted] 9/06-8/08.

From Wind to Whales: The Center for Integrated Marine Technologies to Understand California. [redacted]. NOAA-Center for Integrated Marine Technology. 08/01/06-07/30/07.

Costa Spur Antarctica. Feature on the Antarctic Continent named in recognition of the contribution of D. Costa to Antarctic Research.

2005 Elephant seals as ocean sensors in polar regions. National Undersea Research Program-NOAA. [redacted] 3/05-01/06.

Habitat Utilization of Southern Ocean Seals: Foraging Behavior of Crabeater and Elephant Seals Using Novel Methods of Oceanographic Data Collection. NSF Polar Programs. [redacted]. 8/05-7/08.

Understanding Apex Predator and Pelagic Fish Habitat Utilization in the California Current System by Integrating Animal Tracking with in situ Oceanographic Observations. National Oceanographic Partnership Program ONR. [redacted]. 4/05-04/08.

2004 ***The Census of*** *Marine Life Project* Tagging of Pacific Pelagics Phase II: Pilot Demonstration Projects, Data Management, Education and Outreach. Packard Foundation 6/04-05/07 [redacted] Co PI with B. Block at Stanford University.

Foraging Ecology of the California Sea Lion: Diet, Diving Behavior, Foraging Locations and Predation Impacts on Fishery Resources. [redacted]. California Sea Grant College Program 9/04-8/06.

Tagging Of Pacific Pelagics Phase II, Gordon and Betty Moore Foundation 7/04-06/07 [redacted] Co PI with B. Block at Stanford University.

Tagging of Pacific Pelagics: Using Organisms as Bioprobes for the Ocean Environment. NOAA Office of Ocean Exploration. [redacted] 07/01/04-06/30/05.

2003 TOPP Phase II: Infrastructure, Data Management and International Collaboration 2003-2005. [redacted] Alfred P Sloan Foundation. 07/01/03-06/30/06**.** Co PI with B. Block at Stanford University.

2002-2006 Secretary Society of Marine Mammalogy

2002 From Wind to Whales: The Center for Integrated Marine Technologies to Understand California. [redacted] NOAA-Center for Integrated Marine Technology. 08/01/02-07/30/05.

Accelerating Electronic Tag Development for tracking Free-Ranging Marine Animals at Sea. National Oceanographic Partnership Program (NOPP), Office of Naval Research. [redacted]. 4/02-3/05.

Tagging of Pacific Pelagics. Packard and Sloan Foundation [redacted]. 9/2001-6/2003.

2000 Foraging ecology of crabeater seals (*Lobodon carcinophagus*). National Science Foundation, Division of Polar Programs [redacted] January 2001- June 2004.

A data base for the study of marine mammal behavior: A tool to define their critical habitat and behavior. Office of Naval Research. [redacted] 8/1/00-9/31/02

1999 Comparative Foraging Ecology of the Australian Sea Lion and New Zealand Fur Seal. National Geographic Society. [redacted].

Tools of the Assessment of Marine Mammal Critical Habitats. Office of Naval Research, 6/1/99 - 5/31/02, [redacted]

Dissertation Research: Foraging Ecology of Procellariiform Seabirds: Impacts on Reproduction and Life History. National Science Foundation, 2/1/99 - 1/31/00, [redacted].

Foraging Ecology of Wandering Albatrosses, *Diomedea exulans.* National Science Foundation, Division of International Programs, 2/1/99 – 1/31/01, $[redacted].

1998 Biological Oceanography and Foraging Ecology of Northern Elephant Seals: Patch Use and the Relationship to Oceanographic Features and Elephant seals as a Biological Autonomous Underwater Sampling System. Institute of Marine Sciences, Packard Endowment for Ocean Science and Technology, [redacted]

Acoustic Ecology and Remote Acoustic Monitoring of a Minke Whale Population. Office of Naval Research, 7/25/98 - 9/30/99, [redacted]

University Research Support for High School Science, Subcontract from CSUMB, National Science Foundation, 9/98 - 5/00, $59,989.

Foraging Energetics of Male and Female Wandering Albatross, *Diomedea exulans.* National Geographic Society, [redacted]

The role of oceanographic features and prey distribution on foraging energetics and reproductive success of the Antarctic fur seal, *Arctocephalus gazella*. National Science Foundation, Division of Polar Program Antarctic Biology, 9/1/98 - 8/31/01 [redacted]

The Effect of the 1997/98 El Niño on U.S. Coastal areas. National Oceanic and Atmospheric Administration, 2/19/98 - 2/18/99, $5[redacted]

1996 Marine Mammal Studies in the Central California National Marine Sanctuaries. National Oceanic and Atmospheric Administration, Marine Sanctuaries Program, [redacted]

Elected Fellow, California Academy of Sciences.

1995 The Importance of Foraging Pattern of Reproductive Success in the Northern Fur Seal, *Callorhinus ursinus*. National Science Foundation, Division of Polar Program Arctic Biology, 6/95 - 5/98, $[redacted].

Office of Naval Research, AASERT award for graduate student research support. 5/95 - 4/98, [redacted]

1994 Nominated by White House to serve as U.S. Commissioner on the Inter-American Tropical Tuna Commission.

The Physiology of Freely Diving Beluga Whales. Office of Naval Research, 9/94 - 8/97, [redacted].

Scripps Institution of Oceanography, Marine Mammal Research Program component of Acoustic Thermometry of the Ocean Climate (ATOC), 2/94 - 9/96, [redacted]

1993	The Low Frequency Sound Marine Environment of the Northern Elephant Seal. Office of Naval Research, 1/94 - 12/97 [redacted].
1992	Seed Money Award, Dean Graduate and Research Division, UCSC, [redacted]
1991	Nominated for Member at Large, Society for Marine Mammalogy.
1990	Free-Ranging Energetics of the Bottlenose Dolphin. National Science Foundation, Biological Oceanography, 6/91 - 7/93, $[redacted]
	Ground Truth of Sea Otter Boat Surveys. U.S. Dept. of Justice, August 1990, [redacted]
	Research in Pinniped Biology and Cognition and Physiology. Center for Field Studies, 6/90 - 5/91, [redacted]
	Foraging Energetics of Australian Sea Lions. National Geographic Society, 12/89 - 12/90, $14,500.
1989	Research in Marine Mammal Behavior Cognition and Physiology. Center for Field Studies, 6/89 - 5/90, [redacted]
	Senior Summer Faculty Fellowship, U.S. Navy, American Association Engineering Education, $[redacted].
1988	Seed Money Award, Dean Graduate and Research Division, UCSC, [redacted].
1987	Senior Summer Faculty Fellowship, U.S. Navy, American Association Engineering Education, [redacted]
	Nutritional Energetics and Thermal Requirements of Marine Mammals. Office of Naval Research, 2/87 - 1/90, [redacted].
	Bioenergetics of the Antarctic Fur Seal. National Science Foundation, Polar Programs, [redacted]
1986	Research Opportunity Award, Dean, Division of Natural Sciences, UCSC, [redacted]00.
	Foraging Biology of the Little Penguin in Australia. University Research Expeditions, UREP Grant, [redacted]
	Nominated for Secretary-Treasurer, Society for Marine Mammalogy.
	Current Methods in Pinniped Bioenergetics. National Science Foundation, Physiological Ecology Symposium, 1/86 - 12/86, [redacted]
1985	Studies of the Energetic Cost of Net Entanglement of Northern Fur Seals in Marine Debris. National Oceanic and Atmospheric Organization, NMFS, 9/85 - 9/86, [redacted]
	Research Opportunity Award, Dean, Division of Natural Science, UCSC, [redacted]
1984	Foraging Energetics of the Little Penguins in Australia. University Research Expeditions Program, UREP Grant, [redacted]
1983-86	Assessment of the Impact of the California Sea Lion and Elephant Seal on Commercial Fisheries. California Sea Grant College Program, 10/83 - 9/86, [redacted].
	California Sea Grant College Program, Graduate traineeship, 10/83 - 9/86, [redacted]
	Bioenergetics of the Antarctic Fur Seal. National Science Foundation, Polar Programs, 9/83 - 2/86,[redacted].
1981-83	Bioenergetics of the Northern Fur Seal, *Callorhinus ursinus*. National Oceanic and Atmospheric Organization, National Marine Fisheries Service, 6/81 - 5/83,[redacted].
1979-82	Bioenergetics of Fasting and Lactation in the Fur Seal and Elephant Seal. National Institutes of Health Postdoctoral Research Fellowship, 9/79 - 9/82,[redacted].
1979	Antarctic Service Medal.
1978-80	Effects of Oil Contamination on Free-Ranging Sea Otters, *Enhydra lutris*. National Oceanic and Atmospheric Administration, Outer Continental Shelf Environmental Assessment Program, 10/78 - 6/80, [redacted].
1977	Prize of Excellence, 58th Annual Meeting AAAS Pacific Division for paper entitled, "Ecological Energetics of the California Sea Otter."

1976-77 Ecological Energetics of the California Sea Otter, *Enhydra lutris*. U.S. Fish and Wildlife Service, 4/76 - 5/77, [redacted]

1975-77 Graduate Fellowship, California State Scholarship and Loan Commission.

1970 Bausch and Lomb Science Award.

PATENTS

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Goebel, M.E., Costa, D.P., Crocker, D.E. Sterling, J.E. and Demer, D.A. 2000. Foraging ranges and dive patterns in relation to bathymetry and time-of-day of Antarctic fur seals, Cape Shirreff, Livingston Island Antarctica. In: *Antarctic Ecosystems: Models for Wider Ecological Understanding*. W. Davisons, C. Howard-Williams, and P. Broady, eds. New Zealand Natural Sciences Press: Christchurch New Zealand: pp. 47-50.

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Anderson, S.A., Costa, D.P., and Fedak, M.A. 1993. Bioenergetics. In: *Antarctic Pinnipeds: Research Methods and Techniques*. R. Laws, ed. Cambridge University Press: Cambridge, England; pp. 291-315.

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Costa, D.P. 1987. Isotopic methods for quantifying material and energy intake of free-ranging marine mammals. In: *Approaches to Marine Mammal Energetics*. A.C. Huntley, D.P. Costa, G.A.J. Worthy and M.A. Castellini, eds. Allen Press: Lawrence, Kansas; pp. 43-66.

Costa, D.P. and Gentry, R.L. 1986. Ch. 5. Free-ranging energetics of northern fur seals, *Callorhinus ursinus*. In: *Fur Seals: Maternal Strategies on Land and at Sea*. R.L. Gentry and G.L. Kooyman, eds. Princeton University Press: Princeton, New Jersey; pp. 79-101.

Gentry, R.L., Costa, D.P., Croxall, J.P., David, J.H.M., Davis, R.W., Kooyman, G.L., Majluf, P., McCann, T.S., and Trillmich, F. 1986. Ch.15 Synthesis and conclusions. In: *Fur Seals: Maternal Strategies on Land and at Sea*. R.L. Gentry and G.L. Kooyman eds., Princeton University Press: Princeton, New Jersey; pp. 220-264.

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<u>Book Reviews</u>

<u>Other Publications from Costa's Laboratory</u>

Shaffer, S. A. 2004. Annual energy budget and food requirements of breeding Wandering Albatrosses (*Diomedea exulans*). Polar Biology 27:253-256.

Shaffer, S. A. 2003. Eye of the albatross: visions of hope and survival by Carl Safina - A review. Marine Ornithology 31: 92.

Angelier, F., Shaffer, S. A., Weimerskirch, H., and Chastel, O. 2006. Effect of age, breeding experience and senescence on corticosterone and prolactin levels in a long-lived seabird: the wandering albatross. General and Comparative Endocrinology 149:1-9.

Baker, J. D. and Donohue, M.J. 2000. Ontogeny of swimming and diving in northern fur seal (*Callorhinus ursinus*) pups. Canadian Journal of Zoology 78(1): 100-109.

<u>Publications with Reference to Costa, D.P.</u>

Knight, K. 2018. Collapsing seal lungs protected by amazing anti-inflammatory blood serum. The Journal of Experimental Biology **221**.

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Sea Animals Get Tagged for Double-Duty Research. 2006. Science 313:1383-1384.

Wanderers on the Ocean Wind. 2002. National Geographic September 2001

Online marine resources could soon be swimming with data. 2002. Nature 415:4

Minke Whales make Star Wars noises. 2001. Science News 159:376

<u>Technical Reports</u>

Costa, D.P. 2001. Report of R/V Lawrence M. Gould Cruise LMG01-06 to the Western Antarctic Peninsula 21 July to 1 September 2001, United States Southern Ocean Global Ocean Ecosystems Dynamics Program, Report Number 3, Old Dominion University Norfolk, VA

Costa, D.P. 2002. Report of R/V Lawrence M. Gould Cruise LMG01-06 to the Western Antarctic Peninsula 29 July to 19 September 2002 United States Southern Ocean Global Ocean Ecosystems Dynamics Program, Report Number 7, Old Dominion University Norfolk, VA

Block, B., Costa, D., Boehlert, G. and Kochevar, R. 2001. A report on the tagging of Pacific pelagics (TOPP) workshop. A pilot project for the census of marine life, Monterey California, November 12-14, 2000.

Costa, D.P. 1988. Assessment of the impact of the California sea lion and northern elephant seal on commercial fisheries. Pages 36-43. In: *California Sea Grant: Biennial Report of Completed Projects 1984-86*. California Sea Grant College Program, University of California, La Jolla Publication # R-CSCP-024.

Graduate Students:

Student	Department	Degree Program	Year	Co-Sponsor
Kelly Keen	EE.Biology	Ph.D.	2018-	
Theresa Tatom-Naecker	EE Biology	Ph.D.	2018-	R. Wells
Theresa Keates	Ocean Sciences	Ph.D.	2018	
Jessica Kendall-Bar	EE Biology	Ph.D.	2017-	T. Williams
Arina Favella	EE Biology	Ph.D.	2017-	
Logan Palin	EE Biology	Ph.D.	2017-	A. Friedlander
Michelle Modest	EE Biology	Ph.D.	2017-	A. Friedlander
Theresa Keates	Ocean Sciences	MSc (2018)	2016-2018	
Rachel Holser	EE Biology	Ph.D.	2014-	
Sarah Kienle	EE Biology	Ph.D.	2013-	R. Mehta
Caroline Casey	EE Biology	Ph.D. (2018)	2013-2018	C. Reichmuth
Elizabeth McHuron	EE Biology	Ph.D. (2016)	2012-2016	
Claudio Rojas	EE Biology	Ph.D.	2011-2016	
Michael Tift	EE Biology	Ph.D.	2011-12	
Justine Jackson-Ricketts	EE Biology	Ph.D. (2017)	2010-17	
Sarah Peterson	EE Biology	Ph.D. (2015)	2010-2015	
Melinda Connors	Ocean Science	Ph.D. (2015)	2009-2015	Shaffer
Chandra Goetsch	EE Biology	Ph.D. (2018)	2009-2018	
Kim Goetz	EE Biology	Ph.D. (2015)	2009-2015	
Nicole Teutschel	EE Biology	M.A.	2009-2010	
Melinda Fowler	EE Biology	Ph.D. (2012)	2007-2012	Crocker
Jennifer Maresh	EE Biology	Ph.D. (2014)	2005-2014	Williams
Luis Huckstadt	Ocean Science	Ph.D. (2012)	2005-2012	
Sara Maxwell	Ocean Science	Ph.D. (2010)	2005-2010	
Cory Champagne	EE Biology	Ph.D. (2011)	2005-2011	Crocker
Michelle Kappes (Antolos)	EE Biology	Ph.D. (2009)	2005-2009	Shaffer
Autumn-Lynn Harrison	EE Biology	Ph.D. (2012)	2005- 2012	
Stella Villegas	EE Biology	Ph.D. (2009)	2004-2009	
Birgette McDonald	EE Biology	Ph.D. (2009)	2004-2009	

Patrick Robinson	EE Biology	Ph.D. (2009)	2004-2009	
Andreas Walli	Ocean Science	Ph.D. (2007)	2004-2007	
Jason Hassrick	EE Biology	Ph.D. (2011)	2004-2011	
Samantha Simmons	EE Biology	Ph.D. (2008)	2003-2008	
Samantha Simmons	Ocean Science	M.Sc (2003)	2001-2003	
Michael Weise	EE Biology	Ph.D. (2006)	2001-2006	
Christopher Lester	EE Biology	M.A. (2004)	2001-2004	
Carey Kuhn	EE Biology	Ph.D. (2006)	1999-2006	
Shannon Fowler	EE Biology	Ph.D. (2005)	1999-2005	
Mary Cashman	EE Biology	M.A. (2003)	2000-2002	
Jason Gedamke	Ocean Science	Ph.D. (2004)	1997-2004	
Jill Pettinger	Ocean Science	MSc. (2000)	1997-2000	B. Le Boeuf
Scott Schaffer	Biology	Ph.D. (2000)	1996- 2000	T. Williams
Sylvia Laano	Biology	Ph.D.	1995-97	T. Williams
Mary Donohue	Biology	Ph.D. (1998)	1995-98	
Mary Donohue	Biology	M.A. (1997)		
Scott Shaffer	Marine Science	M.Sc (1996)	1994-96	T. Williams
Tristin Moore	Marine Science	M.Sc (1998)	1994-97	R. Wells
Jennifer Jolly	Marine Science	MSc (1997)	1994-97	B. Le Boeuf
Karen Morris	Biology	M.A. (1998)	1994-97	B. Le Boeuf
Sean Hayes	Biology	Ph.D. (2003)	1994-2002	B. Le Boeuf
Sean Hayes	Biology	M.A. (1998)		
Dorian Houser	Biology	Ph.D. (1999)	1994-98	
Paul Webb	Biology	Ph.D. (1999)	1994-99	B. Le Boeuf
Greg Golet	Biology	Ph.D. (2000)	1994-99	J. Estes
Michael Goebel	Biology	Ph.D. (2003)	1993-1998	
Dan Munson	Marine Science	MSc. (1995)	1992-95	J. Estes
Jocelyn Vedder	Marine Science	MSc (1996)	1992-96	R. Wells
Maria Kretzman	Biology	Ph.D. (1998)	1991-98	B. Rice
Dan Crocker	Biology	Ph.D. (1995)	1991-95	B. Le Boeuf
Jennifer Hurley	Biology	Ph.D. (1996)	1991-96	
Danielle Waples	Marine Science	MSc (1996)	1991-95	R. Wells
Paul Webb	Marine Science	MSc (1994)	1991-94	B. Le Boeuf
Nancy Naslund	Marine Science	MSc (1993)	1989-93	
Jeannine Williams	Biology	Ph.D. (1995)	1989-95	
Dan Crocker	Marine Science	MSc (1992)	1989-92	B. Le Boeuf
Alexis Barbour	Marine Science	MSc (1993)	1989-93	
David Dorado	Biology	Ph.D.	1988-92 (M.A.)	
Sean Adams	Marine Science	MSc (1990)	1988-90	
John A. Liao	Marine Science	MSc (1990)	1987-90	
Lorrie D. Rea	Marine Science	MSc (1990)	1987-90	
Maria Kretzmann	Marine Science	MSc (1990)	1987-90	
Lesley Higgins	Biology	Ph.D. (1991)	1986-91	K. Norris
Brian S. Fadely	Marine Science	MSc (1989)	1986-88	
David Murnane	Marine Science	Masters	1985-87	

Postdoctoral Fellows:

Dr. Roxanne Beltran	2018-present
Dr. Elizabeth McHuron	2016-2017
Dr. Jen Maresh	2014-2016
Dr. Stella Villegas-	2013-2017
Dr. Luis Huckstadt	2012-present
Dr. Sara Maxwell	2010-2011
Dr. Patrick Robinson	2009-2012
Dr. Greg Breed	2009-2011
Dr. Lisa Schwarz	2009-2014
Dr. Gitte McDonald	2009-2010
Dr. Samantha Simmons	2008-2009
Dr. Carey Kuhn	2006-2007
Dr. Mike Weise	2006-2008
Dr. Ken Yoda	2005-2007
Dr. Yoko Mitani	2004-2006
Dr. Yann Tremblay	2003-2008
Dr. Scott Shaffer	2000-2004
Dr. Kelly Jaakola	1997-99
Dr. Jennifer Burns	1997-2000
Dr. Jennifer Hurley	1996-97
Dr. Dawn Goley	1996-97
Dr. Daniel Crocker	1995-97
Dr. Lesley Higgins	1994-96
Dr. Lorrie Wickham	1992-94
Dr. Steve Feldkamp	1986-88
Dr. Graham Worthy	1987-90

Michael D. Harris, Senior Environmental Scientist (Specialist)
California Department of Fish and Wildlife
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PROFESSIONAL EXPERIENCE

April 2012-present: California Department of Fish and Wildlife, Morro Bay California
Senior Environmental Scientist (Specialist). Provide expertise and management of the State's sea otter field research program. Develop and conduct complex investigations and analysis of environmental issues in relation to oil spills, spills of other pollutants and associated impacts on sea otters and other marine sentinel species. Manage CDFW's monitoring program for recovery of dead sea otters and other sentinel species, and participates in postmortem examination of the dead animals. As the Department's sea otter expert, participated in development and operation of the marine ecosystem health program for coastal California in cooperation with other State, federal agencies, and universities. Manage the State's role in the capture, tagging and sampling of sea otters and other marine vertebrates as needed for research and management actions, including but not limited to those resulting from pollution incidents or chronic releases of chemical and biological pollutants into the environment. Duties require maintenance of SCUBA and CCR-100% oxygen rebreather diving certification.

June 2001-April 2012: California Department of Fish and Game, Morro Bay, California
Environmental Scientist C. Under direction of the Office of Spill Prevention and Response, Veterinary Services, develop and conduct complex investigations and analysis of environmental issues in relation to oil spills, spills of other pollutants and associated impacts on sea otters and other marine sentinel species. Develop, perform and report on GIS-based aerial, boat and ground surveys for species sensitive to oil in the environment; perform sea otter and sentinel species carcass recovery and postmortem examination; perform capture, sampling and marking of sensitive species (emphasis on sea otters); perform all aspects of wildlife oil spill response, and maintain oil spill response equipment including boats and specialized wildlife capture and rescue equipment. Produce presentations and reports. CDFG-certified SCUBA and rebreather diver.

July 1997 to June 2001: Calif. Department of Fish and Game (contract), Morro Bay, California
Sea Otter Biologist. Coordinate and conduct studies on sea otter biology and natural history pertinent to conservation and management issues, including population dynamics, population health assessment, food habits, natural resource damage assessment, and fishery interactions. Assist CDFG Vet Services with oil spill response involving wildlife. Produce presentations and reports. CDFG-certified SCUBA and Rebreather diver.

August 1991 to June 1997: California Department of Fish and Game, Morro Bay, California
Scientific Aid. Sea Otter Research Project. Perform studies on sea otter biology and natural history pertinent to natural resource damage assessment, conservation and management issues including population dynamics, mortality, food habits, and fishery interactions. Produce presentations and reports.

July 1995 to June 2001: United States Fish and Wildlife Service (contract), Ventura, California
Marine Biologist. Coordinate sea otter mortality study activities in southern portion of their range.

March 1995 to 2000: Coastal Resources Management (contract), Corona del Mar, California
Marine Biologist. Conduct diving surveys assessing impacts on eelgrass communities from dredging and construction projects; implement and monitor mitigation measures. Conduct subtidal surveys of nearshore benthic communities affected by construction and operation of a desalination plant. Provide consultation on impacts to sea otters from described projects.

August 1996 to July 1998: Tenera, Avila Beach, California
Senior Research Associate. Perform intertidal and diving surveys of benthic marine communities to assess operation affects of a nuclear power plant.

February 1995 to July 1996: Entrix Environmental, Walnut Creek, California
Environmental Technician. Conducted field surveys assessing impacts from petroleum products on intertidal and subtidal marine communities.

October 1994 to March 1995: Science Applications International Corporation, S.B., California
Marine Biologist. Provided consultation on impacts to sea otters from installation of the nearshore leg of a trans-Pacific telephone cable. Monitored project activities within sea otter habitat and provided written report.

May 1991 to December 1993: Hanson Environmental, Walnut Creek, California
Fisheries Technician. Conducted fishery surveys and habitat mapping of the Santa Ynez River. Conducted thermotolerance experiments on fingerling Chinook salmon.

EDUCATION

California Polytechnic State University, San Luis Obispo. Bachelor of Science in Biological Sciences, concentrating in Marine Biology, December 1990.

PUBLICATIONS AND TECHNICAL REPORTS

2015 Tinker, M. T., Hatfield, B.B., **Harris, M. D**., Ames, J.A. Dramatic increase in sea otter mortality from white shark in California. Marine Mammal Science. 32(1): 309-326.

2014 Henkel, L., **Harris, M.D.**, Ames, J., Ford, R.G., Staedler, M., Tinker, M.T. Use of decoys to assess effectiveness of aerial surveys for sea otters. California Department of Fish and Wildlife, Office of Spill Prevention and Response Technical Report 14-2.

2013 Miller, M.A., Dodd, E., Batac, F., Young, C., **Harris, M.D**., Kunz, J., Berberich, E., Henkel, L**.** Summary of Southern sea otter mortality investigations in 2012. California Department of Fish and Game, Office of Spill Prevention and Response Technical Report 13-1.

2011 Hatfield B.B., Ames J.A., Estes J.A., Tinker M.T., Johnson A.B., Staedler M.M., **Harris M.D**. Sea otter mortality in fish and shellfish traps: Estimating potential impacts and exploring possible solutions. Endangered Species Research. 13:219-229.

2010 Miller M.A., Conrad P.A., **Harris M.**, Hatfield B., Langlois G., Jessup D.A., Magargal S.L., Packham A.E., Toy-Choutka S., Melli A.C., Murray M.A., Gulland F.M., Grigg M.E. A protozoal-associated epizootic impacting marine wildlife: mass-mortality of southern sea otters (Enhydra lutris nereis) due to Sarcocystis neurona infection. Vet Parasitol. 172(3-4): 183-94.

2009 Miller M.A., Jang S., Byrne B., Dodd E., Dorfmeier E., **Harris M.**, Ames J., Paradies D., Worcester K., Jessup D.A., Miller W. Exposure to heavy freshwater runoff and dense coastal human populations are significant risk factors for enteric bacterial pathogen infection in California sea otters (Enhydra lutris nereis). Vet. Res. (2010) 41:01.

2008 Miller M.A., Miller W.A., Conrad P.A., James E.R.., Melli A.C., Leutenegger C.M., Dabritz H.A., Packham A.E., Paradies D**., Harris M.**, Ames J., Jessup D.A., Worcester K., Grigg M.E. Type X Toxoplasma gondii in a wild mussel and terrestrial carnivores from coastal California: New linkages between terrestrial mammals, runoff and toxoplasmosis of sea otters. Int. J. Parasitol. 38: 1319-28. COVER ARTICLE. MOST CITED MANUSCRIPT: 2008-2010.

2006 Miller, W.A., Miller M.A., Gardner I.A., Atwill E.R., Byrne B.A., Jang S., **Harris M**., Ames J., Jessup D., Paradies D., Worcester K., Melli A., Conrad P.A. Salmonella spp., Vibrio spp., Clostridium perfringens, and Plesiomonas shigelloides detected in freshwater and marine invertebrates from coastal California ecosystems. Microb. Ecol. 52(2): 198-206.

2005 Miller, W.A., Miller M.A., Gardner I.A., Atwill E.R., **Harris M.,** Ames J., Jessup D.A., Melli A.C., Paradies D., Worcester K., Olin P., Barnes N.M. Conrad P.A. New genotypes and factors associated with Cryptosporidium detection in mussels (Mytilus spp.) along the California coast. Int. J. Parasitol. 35:1103-1113.

2004 Jessup D.A., Miller M.A., Ames J.A., **Harris M**., Kreuder C., Conrad P.A., Mazet J.K. The southern sea otter (Enhydra lutris nereis) as a sentinel of marine ecosystem health. Ecol. and Health. 1:239-245.

2004 Olson M.E., Appelbee A., Measures L., Cole R.A., Lindsay D.S., Dubey J.P., Thomas N.J., Miller M.A., Conrad P.A., Gardner I.A., Kreuder C., Mazet J., Jessup D., Dodd E., **Harris M.**, Ames J., Worcester K., Paradies D., Grigg M., Fayer R., Lewis E.J., Trout J.M., Xiao L., Howard D.W., Palmer R., Ludwig K., Tyler S.S. Zoonotic protozoa in the marine environment: A threat to aquatic mammals & public health. Eds: R. Fayer, D. Lindsay. Vet. Parasitol. 125: 131–135.

2003 Kreuder C., Miller M.A., Jessup D.A., Lowenstine L.J., **Harris M.D,** Ames J.A., Carpenter T.E., Conrad P.A., Mazet J.K. Patterns of mortality in southern sea otters (Enhydra lutris nereis) from 1998–2001. J. Wildl. Dis. 39:495-509.

2002 Miller, M.A., Gardner I.A., Kreuder C., Paradies D.M., Worcester K.R., Jessup D., Dodd E**., Harris M.D.**, Ames J.A., Packham A.E., Conrad P.A. Coastal freshwater runoff is a risk factor for Toxoplasma gondii infection of southern sea otters (Enhydra lutris nereis). Int. J. Parasitol. 32:997-1006.

1997 Pattison, C. A., **Harris, M. D**., Wendell, F. E. Sea Otter, Enhydra lutris, mortalities in California, 1968 through 1993. California Department of Fish and Game Marine Resources Division, Marine Resources Division Administrative Report, 97-5

1996 Wendell, F., Pattison, C., and **Harris, M.** Sea otter, Enhydra lutris, containment management: field studies and feasibility assessment. California Department of Fish and Game Marine Resources Division, Marine Resources Division Administrative Report, 96-5.

Curriculum Vitae for Marissa Young
Monterey Bay Aquarium
886 Cannery Row
Monterey, CA 93940
(831) 647-6881

Objective:
The goal of the Registered Veterinary Technician position: to provide veterinary technician expertise to the living collection of animals, to manage the Animal Health Laboratory, to support MBA live animal research activities, and to undertake related husbandry program support activities.

Professional Employment:
August 2005-present Monterey Bay Aquarium, Monterey, CA
Registered Veterinary Technician

- Perform Registered Veterinary Technician activities in support of a comprehensive veterinary medical program for the living animal collection. Perform monitoring for anesthetic procedures. Coordinate ordering of medical supplies and processing of diagnostic tests, manage pharmaceutical supplies, and maintain all relevant records and logs. Effect the maintenance of all veterinary medical and laboratory equipment; maintain, clean, and disinfect Animal Health Lab, Diagnostic Lab, and associated medical equipment. Work closely with veterinarian to detect medical problems, assist with veterinary procedures, and administer medical treatments. Perform routine laboratory testing using MBA facilities and equipment as directed by veterinarian. Take radiographs, maintain radiographic equipment and logs, and assure compliance with local, state, and federal regulations related to radiographic equipment and safety. Manage veterinary drugs and supplies to include ordering, inventory, accounting, and disposal. Coordinate training of staff and volunteers in veterinary medical support activities (e.g., injections, fluid therapy, surgical support, etc.). Provide professional veterinary technician support for in and ex situ research projects. Undertake all relevant data entry and record keeping for veterinary medical program. Maintain/manage serum/tissue bank of archived biological samples: coordinate archive; maintain records/database; work with veterinarian to deliver samples to researchers. Respond to stranded sea otter calls in the roll of a veterinary technician supporting the veterinarian. Interpret Animal Health Lab and Diagnostic Lab activities to the public. Undertake data entry and statistical analysis of data for the institution's veterinary program. Work independently and as an integral part of the veterinary program. Participate in planning for short- and long-term departmental goals. Interact and exchange information with colleagues. Participate in MBA public relations and educational activities, as needed. Participate in research projects or administrative tasks, as needed. Perform other MBA tasks, as needed
- 8/2005 to 9/2011: SORAC Animal Care Specialist: Provide medical and husbandry care for live-stranded sea otters, supervise and train volunteers in proper medical and husbandry practices for in-house animals. Clean and maintain sea otter holding tanks and SORAC food prep room. Participate in sea otter fieldwork including capture, release and tracking of animals, respond to dead and live animal strandings.

May 2004-August 2005 Ocean View Veterinary Hospital, Pacific Grove, CA
Registered Veterinary Technician

- Responsible for cleaning cages, administering medical treatments and feeding in-house patients, surgical prep and assistance, anesthetic induction and monitoring, endotracheal intubation, phlebotomy, radiography, animal restraint, placement of intravenous catheters, dental prophylaxis and tooth extraction. Perform general laboratory work including urinalysis, fecal flotation, hematology, serum chemistry, and electrolyte analysis. Other duties include administration of vaccinations, client education, equipment maintenance, staff and volunteer training, computer data entry, and maintaining accurate animal medical records.

June 1999-May 2004 — Klaich Animal Hospital, Reno, NV
Registered Veterinary Technician

- Assist with general medical exams, animal restraint, administration of vaccinations, client education, anesthetic induction and monitoring, surgical prep and assistance, endotracheal intubation, phlebotomy, radiography, placement of intravenous catheters, dental prophylaxis, and administration of medications. Clean and maintain animal housing areas, oversee patient nutrition, equipment maintenance, perform laboratory diagnostics including hematology, serum chemistry, electrolyte analysis, and fecal flotation. Train staff, volunteers, and student interns, maintain proper animal medical records and an accurate controlled drug log.

Education:

Jan-Dec 2000	Community College of Southern Nevada, Las Vegas, NV Certificate of Achievement, Animal Health Technology
1997-1999	University of Nevada, Reno; Reno, NV Bachelor of Science in Ecology and Conservation Biology
1995-1997	Oregon State University, Corvallis, OR Undergraduate study

State Licensure:

Registered Veterinary Technician, State of California
September 2004-present
License Number: 6589

Registered Veterinary Technician, State of Nevada
March 2001-December 2004
License Number VT200

Professional Affiliations:

Association of Zoo Veterinary Technicians (AZVT)
California Registered Veterinary Technician Association (CaRVTA)
Association of Zoos and Aquariums (AZA)

Continuing Education:

Wild West Veterinary Conference, Reno, NV: 2000, 2001, 2002, 2004
Wildlife Veterinary Resources: Wildlife Handling and Chemical Immobilization for Veterinary Technicians; Forest Lake, MN October 2001
Western Veterinary Conference, Las Vegas, NV: February 2003, February 2015
Basic Wildlife Rehabilitation 1AB, International Wildlife Rehabilitation Council, San Luis Obispo, CA June 2003

Southern Sea Otter Symposium, Santa Cruz, CA 2005, 2006, 2007, 2009, 2010, 2012, 2014, 2016
Association of Zoo Veterinary Technicians Annual Conference, Toledo, OH September 2006
Oiled Wildlife Care Network, Basic Skills Training. Certificate of Completion, Cordelia, CA October 28-29, 2006
Reptilian and Amphibian Internal and External Parasitology, VSPN.org online course, Feb 15-March 10, 2007
Association of Zoo Veterinary Technicians Annual Conference, Honolulu, HI September 2007
Basic Fish Medicine, VSPN.org online course May 20-June 17, 2008
Association of Zoo Veterinary Technicians Annual Conference, New Bedford, MA October 2008
Association of Zoo Veterinary Technicians Annual Conference, Jackson Hole, WY October 2009
Association of Zoo Veterinary Technicians Regional Conference, Los Angeles, CA October 2010
Association of Zoo Veterinary Technicians Annual Conference, Tulsa, Oklahoma September 2016
Association of Zoo Veterinary Technicians Annual Conference, Columbus, OH August 2018
Diagnostic Cytology for Veterinary Practitioners, Abaxis University online webinar, February 8, 2011
Treating Blood Gas Dyscrasias, Abaxis University online webinar, April 19, 2011
Clinical Pathology for Reptiles, Abaxis University online webinar, January 25, 2012
Oiled Sea Otter Care Workshop, OWCN training seminar, February 10, 2012
UC Davis/SFSPCA Spring Veterinary Symposium, May 6, 2012
Reptile Hematology, VSPN.or online course; July 2012
Digital Radiology, Idexx Webinar series; September 2012
UC Davis Back-to-School RVT Seminar; July 2012, June 2013
Avian Hematology, VSPN.org online course; November 2015
Sea Otter Conservation Workshop, Seattle Aquarium, Seattle, WA March 2017

Presentations:
M. Young, Canine First Aid and Emergency Care. SARCON Western States Search & Rescue Training Conference, Reno/Stead, Nevada, April 22-25, 2004

M. Young, M. Murray, J. Coffey, SORAC Volunteer Medical Training Class, Monterey, CA August 2006, August 2009.

M. Young, Anesthetic Protocols and Monitoring in the Southern Sea Otter, AZVT 26th Annual Conference, Toledo, OH September 2006.

M. Young, Fracture Repair in a Southern Sea Otter, AZVT 26th Annual Conference, Toledo, OH September 2006.

M. Young, Stranding Response for Dependent-Aged Sea Otter Pups, CMMSN Confernce, San Diego, CA February 8-9, 2007.

M. Young, Monterey Bay Aquarium Animal Medical Procedures, People to People Conference, MBA Auditorium Program, Monterey, CA August 13, 2007.

M. Young, Stranding Response and Husbandry Care for Stranded Sea Otter Pups (*Enhydra lutris nereis*), AZVT 27th Annual Conference, Honolulu, HI September 2007.

M. Viens, Investing in Your Volunteers – A Training Program at the Monterey Bay Aquarium, AZVT 28th Annual Conference, New Bedford, MA October 2008.

M. Viens, Malignant Histiocyctic Sarcoma in a Female Southern Sea Otter (*Enhydra lutris nereis*), AZVT 28th Annual Conference, New Bedford, MA October 2008.

M. Viens, Experimental Treatment Protocol for Acanthocephalan Peritonitis in the Southern Sea Otter (*Enhydra lutra nereis*), AZVT 29th Annual Conference, Jackson Hole, WY 2009.

L. Tell, M. Young, What Otter You Waiting For? Long Acting Antibiotics for Sea Otters: Pharmacokinetics of Cefovecin. OWCN Oilapalooza Conference, San Diego, CA 2013.

M. Young, Preventive Health Program for Monitoring Monogenean Parasite Infections in Leopard Sharks (*Triakis semifasciata*) at Monterey Bay Aquarium. AZVT Annual Conference, Columbus, OH 2018.

M. Young, The Animal Care Center at Monterey Bay Aquarium: Justifying the Need for More Space. Poster presentation, AZVT Annual Conference, Columbus, OH 2018.

M. Young, Veterinary Care at the Monterey Bay Aquarium: The New Juli Plant Grainger Animal Care Center. Central Coast Registered Veterinary Technician Association meeting. February 2019.

Publications:
M. Young, Anesthetic Protocols and Monitoring in the Southern Sea Otter, AZVT 26th Annual Conference Proceedings, Toledo, OH September 2006.

M. Young, Fracture Repair in a Southern Sea Otter, AZVT 26th Annual Conference Proceedings, Toledo, OH September 2006.

M. Viens, Sea Otter Research and Conservation, *Veterinary Technician*, June 2008 Volume 29, No. 6

M. Viens, Investing in Your Volunteers – A Training Program at the Monterey Bay Aquarium, AZVT 28th Annual Conference Proceedings, New Bedford, MA October 2008.

M. Viens, Experimental Treatment Protocol for Acanthocephalan Peritonitis in the Southern Sea Otter (*Enhydra lutris nereis*). AZVT 29th Annual Conference Proceedings, Jackson Hole, WY September 2009.

Tyrrell, L. P., Newsome, S. D., Fogel, M. L., Viens, M., Bowden, R., & Murray, M. J. (2013). Vibrissae growth rates and trophic discrimination factors in captive southern sea otters (Enhydra lutris nereis). *Journal of Mammalogy,* 94(2), 331-338.

Lee, E. A., Byrne, B. A., Young, M. A., Murray, M. J., Miller, M. A., Tell, L. A. (2016). Pharmacokinetic indices for cefovecin after single-dose administration to adult sea otters (*Enhydra lutris)*. *Journal of Veterinary Pharmacology and Therapeutics*, 39(6), 625-628.

Volunteer Experience:
Sea Otter Research and Conservation program, Monterey Bay Aquarium, Monterey, CA August 2004-July 2005

- Clean and maintain animal holding tanks, prepare and feed animal diets, animal restraint, administration of medications, respond to animal stranding calls, computer data entry.

Animal Ark Wildlife Sanctuary, Reno, NV October 1999-May 2004

- Clean and maintain animal holding areas, prepare and feed animal diets for a variety of species, assist in the development and implementation of behavioral enrichment protocols, administer vaccinations, perform routine fecal exams on entire animal collection, act as park docent and school group tour leader, assist in the development of educational tours.

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Zachary Howland Randell

Education

Ph.D. Candidate, Integrative Biology, Oregon State University (Fall 2015 - anticipated graduation Spring 2020); Advisor: Dr. Mark Novak

- National Science Foundation Graduate Research Fellow (2016)
- Dr. Earl H. Myers & Ethel M. Myers Oceanographic & Marine Biology Trust Recipient (2019)

BS Biology, University of California Santa Cruz (2012)

- Senior honors thesis: "The effects of light, depth, and age on the distribution and abundance of extracellular polymeric substances found within a California *Macrocystis pyrifera* kelp bed."
- UCSC Diving control board undergraduate representative fall 2010 – fall 2012.

Work Experience

Biological Science Technician – Estes/Tinker Lab, UC Santa Cruz and the U.S. Geological Survey, Western Ecological Research Center, Santa Cruz field station (May 2012 – Sept. 2015)

- Responsible for coordinating sea otter tag tech development efforts between NASA engineers and USGS wildlife biologists (2014-present), with the objective of developing a sea otter flipper tag capable communicating geospatial data off via local networked communication.
- Daily execution of the Santa Barbara Channel (SBC) sea otter research project (May 2012 – April 2014). Responsible for capturing, tracking, and monitoring instrumented sea otters. Required boat and ground-based radio telemetry and visual surveillance.
- Sole resident who lived and maintained a remote field station.
- Participated in sea otter capture operations. Responsible for capturing, handling, transporting, and the release of wild sea otters for multiple long-term sea otter monitoring projects.

Subtidal Technician – Partnership for the Interdisciplinary Study of Coastal Oceans, UC Santa Cruz (June 2010 – Sept. 2011)

- Surveyed subtidal invertebrates and algae, and benthic, midwater, and canopy fishes (137 dives).
- Deployed, maintained, and retrieved oceanographic monitoring equipment.
- Assisted with SMURF (Standard Monitoring Unit for the Recruitment of Fishes) skin diving collection, fish identification, and fin clip sampling for genetic sampling.

Publications

- K. Grorud-Colvert, J. Sullivan, Z. Meunier, A. Rickborn, V. Constant, K. Dziedzic, B. Spiecker, **Z. Randell**, S. Hamilton, H. Fulton-Bennett, J. Lubchenco, S. Bachhuber. High-profile international commitments for ocean protection: Empty promises or meaningful progress? 2019. *Marine Policy*
- S. Gravem; S. Bachhuber; H. Fulton-Bennett; **Z. Randell**; A. Rickborn; J. Sullivan; B. Menge. 2017. Transformative Research Is Not Easily Predicted. *Trends in Ecology and Evolutionary Biology*
- T. Tinker; J. Tomoleoni; N. LaRoche; L. Bowen; **Z. Randell**. Southern Sea Otter Range Expansion and Habitat Use in the Santa Barbara Channel. 2015. Final Report to Bureau of Ocean and Energy Management

Professional Talks and Invited Presentations

- **Z. Randell**, *et al*. "Velocity of community shift and alternative states in southern California kelp forests. Oregon State University, Dept. of Integrative Biology, Spring Seminar invited speaker.
- **Z. Randell,** *et al***. "**Velocity of community shift and alternative states: how long-term monitoring can focus dialogue surrounding nearshore conservation and management" Sea Otter Conservation Workshop, 2019.
- **Z. Randell**. "So you think sea otters are cute? An exclusive expose on the wily weasel of the waves" Biology Graduate Student Symposium, 2018

- **Z. Randell**; M. Kenner; T. Tinker. “Influence of habitat variation on 36 years of subtidal community structure at San Nicolas Island” Ecological Society of America, poster, 2017
- **Z. Randell**; M. Kenner; T. Tinker. “Influence of habitat variation on 35 years of subtidal community structure at San Nicolas Island” Seattle Aquarium Sea Otter Workshop, 2017
- **Z. Randell**; T. Tinker; M. Kenner. “Influence of habitat variation on 35 years of subtidal community structure at San Nicolas Island” California Island Symposium, 2016
- **Z. Randell**; T. Tinker; M. Staedler; M. Murray; L. Carswell; D. Jessup; B. McConnell. “OtterNet update: prototype microcontroller constructed and ready for Implantation” Southern Sea Otter Research Update Meeting (SSORUM), 2016
- **Z. Randell**; T. Tinker; M. Staedler; M. Murray; L. Carswell; D. Jessup; B. McConnell. “Advancing Tag Technology: A Peer-to-Peer Tracking Network for Wild Sea Otters” Society of Marine Mammology, poster, 2015
- **Z. Randell**; T. Tinker; M. Staedler; M. Murray; L. Carswell; D. Jessup; B. McConnell. “Advancing Tag Technology: A Peer-to-Peer Tracking Network for Wild Sea Otters” Sea Otter Conservation Workshop IX, 2015
- **Z. Randell**; T. Tinker; M. Staedler; M. Murray; L. Carswell; D. Jessup; B. McConnell. “Game Changer: Solar Powered Peer-to-Peer Tracking Network for Oiled and Rehabilitated Sea Otters” OWCN Research Symposium, 2015

Service

Within the Department of Integrative Biology during PhD (2015 – present)

- Organized special guest speaker Ken Collins (Microsoft) to give lecture on applying scientific skills towards opportunities in the private sector, 2017
- Biology Graduate Student Symposium committee: 2015, 2017, 2018
- Graduate representative on *ad hoc* Cordley Remodel Committee, 2018
- Graduate representative on *ad hoc* Graduate Curriculum Review Committee, 2019

Community Outreach and Education

- Participated in Science Math Investigative Learning Experiences (SMILE) in 2018
- Helped organize and gave lecture at Integrative Biology Open House 2017 and 2018
- Guest lecturer at Marine Ecology (May 2017) and Marine Biology (March 2018) undergraduate classes at Oregon State
- Guest lecturer for a Marine Conservation undergraduate class at Pacific University (Jan 2017)
- Trained Santa Barbara Zoo volunteers in field protocols to survey and collect wild sea otter data
- Trained CIMWI volunteers in basic animal husbandry
- Organized sea otter and ocean awareness week outreach events at the Santa Barbara Zoo
- Lectured at local K-12 schools on local factors imperiling sea otter recovery

Field Experience

SCUBA certifications and experience

- 504 scientific dives, roughly 75 recreational dives
- 100% O2 rebreather certified for sea otter capture diving operations
- Scientific Certified (100 FSW): UC Santa Cruz 20 Jun 2010, Rescue: UCSC: 3 Oct 2008
- Dry Suit, Rescue, Nitrox, and Open water certified (PADI) Seward, AK: 2005 - 2007

Small boat operator

- 289 separate days operating inflatables, Boston Whalers, Andersons, and Radons (8-25’).
- Motorboat Operator Training Certification (MOTC) Spring 2011, UCSC
- Checked out as primary operator: R/V Terrace Pt., Lucy M., Sebastes, Whitecap, Pursuit.
- Primary operator for UCSC and USGS projects in near shore and open-ocean conditions including skin, SCUBA, and rebreather diver deployment and retrieval.
- Boat trailering, maintenance, and repair – electrical, fiberglass, painting, trailer body, etc.

CURRICULUM VITAE

James L. Bodkin

Scientist Emeritus
Alaska Science Center
Retired
[redacted] hm
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Current Position: Consultant, James L. Bodkin Biological Consulting

Prior responsibilities: Coastal Systems Project Leader. Responsible for the design and implementation of coastal marine research for the Alaska Science Center. Responsibilities include preparation and approval of study plans, supervision of research projects and preparation of results, and publication of results. Responsible for managing coastal systems project staff. Directs coastal systems research annual funding allocations. Southern Alaska Coastal Ecosystem Team Leader.

Previous Positions:

Wildlife Biologist (Research) GS-486-14. Alaska Science Center. U.S. Geological Survey. Anchorage, Alaska. December 2006-November 2012

Wildlife Biologist (Research) GS-486-13. Alaska Biological Science Center. U.S. Geological Survey. Anchorage, Alaska. August 1996-2006.

Wildlife Biologist (Research) GS-486-12. Alaska Biological Science Center. U.S. Geological Survey. Anchorage, Alaska. August 1990-1996.

Wildlife Biologist GS-486-11, Koyukuk/Nowitna National Wildlife Refuge. U.S. Fish and Wildlife Service. Galena Alaska. 1989-1990.

Fish & Wildlife Biologist GS-401-11, National Ecology Research Center, U.S. Fish and Wildlife Service. Santa Cruz field station. 1986-1989

Biological Technician (Wildlife) GS-404-09, National Ecology Research Center, U.S. Fish and Wildlife Service, San Simeon field station. 1980-1986

Biological Technician (Fisheries) GS-404-05, National Marine Fisheries Service, Southwest Fisheries Center, La Jolla, California, 1977-1980

Education:	1985 -MS, California Polytechnic State University, San Luis Obispo, CA. (Wildlife Biology) 1976- BS, Long Beach State University (Biology), Long Beach, CA 1972 - AS, Cypress College (Biology), Cypress, CA
Other Training:	1989 - Arctic Survival Course, US Air Force, Eilson AFB, AK. 1989 - Fire Management Training, USFWS, Kenai, Alaska. 1977-Certified Radio Telephone Operator, third class, Department of Commerce. 1975 -Research Diving Certification, Advanced Professional Association of Diving Instructors (PADI) 1970 -Basic Scuba Certification, National Association of Scuba Diving Schools (NASDS), Research Diving Certification Current certificates in CPR, Oxygen administration and First-aid.
Memberships:	Society for Marine Mammalogy American Society of Mammalogists Society for Conservation Biology Wildlife Society Western Society of Naturalists National Geographic Society Science Advisory Committee, Glacier Bay National Park Alaska Sea Otter Commission, Scientific Advisor USGS National Diving Control Board Member

State and Federal Collecting Permits
Federal Marine Mammal/OMA Permits; PRT 750916 PRT 672624, PRT 710118, PRT 684532, PRT 692350

State Permits; Alaska State Permit 90-69

Publications

Bodkin, J.L. 1984. A comparison of fish assemblages in Macrocystis and Nereocystis kelp forests off central California. MS Thesis. California Polytechnic State University, San Luis Obispo. 98 pp.

Bodkin, J.L., R.J. Jameson and G.R. VanBlaricom. 1985. Pup production, abundance, and breeding distribution of northern elephant seals on San Nicolas Island, Winter 1981. Calif. Fish and Game. 71(1):53-59.

VanBlaricom, G.R., D.C. Reed, C. Harrold and J.L. Bodkin. 1985. A sublittoral population of Pleurophycyus gardneri Setchell and Saunders 1900 (Phaeophyceae: Laminariaceae) in central California. Bull. Southern California Acad. Sci. 84(3).

Bodkin, J.L. 1986. Fish assemblages in Macrocystis and Nereocystis kelp forests off central California. U.S. Fishery Bulletin. 84(4):799-808.

Jameson, R.J. and J.L. Bodkin. 1986. An incidence of twinning in the sea otter (Enhydra lutris). Marine Mammal Science. 2(4):304-309.

Bodkin, J.L., G.R. VanBlaricom and R.J. Jameson. 1987. Mass mortalities of nearshore fishes following period of large, long period storm swells. Environmental Biology of Fishes. 18(1):73-76.

Bodkin, J.L. 1988. Effects of kelp forest removal on associated fish assemblages in central California. Journal of Experimental Marine Biology and Ecology. 117:227-238.

Bodkin, J.L. and F. Weltz. 1990. A summary and evaluation of sea otter rescue operations in response to the Exxon Valdez oil spill, Prince William Sound, Alaska, 1989. Proceedings; Sea Otter Symposium, Anchorage, Alaska, 17-19 April, 1990. pp 61-69.

Bodkin, J.L. and R. Jameson. 1991. Patterns of seabird and marine mammal carcass deposition along the central California coast, 1980-1986. Can J. Zool. 69:1149-1155.

Bodkin, J.L. and L. Browne. 1992. Molt frequency and size-class distribution in the spiny lobster (Panulirus interruptus), at San Nicolas Island, California. California Fish and Game. 78(4):136-144.

Bodkin, J. L., B.E. Ballachey and M. Cronin. 1992. Mitochondrial DNA and the conservation and management of sea otters. Research Information Bulletin No. 37. US Fish and Wildlife Service, Office of Information Transfer.

Bodkin, J. L., D. Mulchay and C.J. Lensink. 1993. Age specific reproduction in the sea otter *(Enhydra lutris)*; an analysis of reproductive tracts. Can. J. Zool. 71(9): 1811-1815.

Cowen, R.K. and J.L. Bodkin. 1993. Annual and spatial variation of the kelp forest fish assemblage at San Nicolas Island, California. Pp 464-474. *In*, F.G. Hochberg (ed.) Third California Islands Symposium: recent advances in research on the California Islands. Santa Barbara Museum of Natural History, Santa Barbara, CA.

Udevitz, M.S., J.L. Bodkin and D.P. Costa. 1995. Sea otter detectability in boat-based surveys of Prince William Sound, Alaska. Marine Mammal Science. 11(1) :59-71.

Ballachey, B.E., J.L. Bodkin and A.R. DeGange. 1994. An overview of sea otter studies. *in* T. Loughlin editor. Marine mammals and the Exxon Valdez. Academic Press. San Diego, CA pages 47-59.

Bodkin, J.L. and M.S. Udevitz. 1994. Intersection model for estimating sea otter mortality along the Kenai Peninsula. *in* T. Loughlin editor. Marine mammals and the Exxon Valdez. Academic Press. San Diego, CA pages 81-95.

Doroff, A.M. and J.L. Bodkin. 1994. Sea otter foraging behavior and hydrocarbon levels in prey. *in* T. Loughlin, editor. Marine mammals and the Exxon Valdez. Academic Press. San Diego, CA pages 193-208.

Cronin, M.A., J.L. Bodkin, B.E. Ballachey, J.A. Estes, and J.C. Patton. 1996. Mitochondrial DNA variation among subspecies and populations of sea otters (Enhydra lutris). J. Mammalogy. 77(2):547-557.

Bodkin, J.L., R.J. Jameson and J,A, Estes. 1994. Sea otters in the North Pacific Ocean. *In* E.T. LaRoe III, G.S. Farris, C.E. Puckett and P.D. Doran, editors. *Our Living Resources 1994: A report to the nation on the distribution, abundance and health of U.S. plants, animals and ecosystems.* National Biological Service. Washington D.C. pages 353-356.

J.A. Estes, R.J. Jameson, J.L. Bodkin and D.R. Carlson. 1994. Status and trends of the California sea otter population. *In* E.T. LaRoe III, G.S. Farris, C.E. Puckett and P.D. Doran, editors. *Our Living Resources 1994: A report to the nation on the distribution, abundance and health of U.S. plants, animals and ecosystems.* National Biological Service. Washington D.C. pages110-112.

Bodkin, J.L., J.A. Ames, R.J. Jameson, A.M. Johnson and G.M. Matson. 1997. Accuracy and precision in estimating age of sea otters using cementum layers in the first premolar. J. Wildlife Management 61(3):967-973.

Bodkin, J.L. and B.E. Ballachey. 1996. Monitoring the status of the wild sea otter population: field studies and techniques. Endangered Species Update. University of Michigan Vol 13(12):14-20.

Estes, J.A., D.F. Doak, J.L. Bodkin, R.J. Jameson, D. Monson, J, Watt and T. Tinker. 1996. Comparative demography of sea otter populations. Endangered Species Update. University of Michigan Vol.13(12):11-13.

Shirley, T.C., C.E. O'Clair, S.J. Taggart, and J.L. Bodkin. 1996. Sea otter predation on Dungeness crabs in Glacier Bay, Alaska. Pgs. 563-576 in: International Symposium on Biology, Management, and Economics of Crabs from High Latitude Habitats. Alaska Sea Grant College Program, Anchorage, Alaska.

Scribner, K.T., J.L. Bodkin, B.E. Ballachey, S.R. Fain, M.A. Cronin and M. Sanchez. 1997. Population and genetic studies of sea otter (*Enhydra lutris*): A review and interpretation of available data. Pages 197-208 *in* A.E. Dizon, S.J. Chivers, and W.F. Perrin, eds. Molecular genetics of marine mammals. Special Publication 3 by the Society for Marine Mammalogy. Allen Press.

Bodkin, J.L. and B.E. Ballachey. 1997. Restoration Notebook Series: Sea Otter (*Enhydra lutris)* Exxon Valdez Oil Spill Trustee Council. Anchorage, AK.

Bodkin, J.L., B.E. Ballachey, M.A. Cronin and K.T. Scribner. 1999. Population demographics and genetic diversity in remnant and re-established populations of sea otters. Conservation Biology 13(6):1278-1385.

Bodkin, J. L. and M.S. Udevitz. 1999. An aerial survey method to estimate sea otter abundance. in: Garner, G.W., S.C. Amstrup, J.L. Laake, B.F.J. Manly, L.L. McDonald, and D.G. Robertson, (eds.) Marine mammal survey and assessment methods. Balkema Press, Netherlands pg. 13-26.

Bodkin, J.L., A.M. Burdin and D.A. Ryzanov. 2000. Age and sex specific mortality and population structure in sea otters. Marine Mammal Science 16(1):201-219.

Monson, D.H., J.A. Estes, J.L. Bodkin and D.B. Siniff. 2000. Life history plasticity and population regulation in sea otters. Oikos. 90:3 457-468.

Adkison, M.D., B. Ballachey, J. Bodkin, and L. Holland-Bartels. 1998. Integrating ecosystem studies: a Bayesian comparison of hypotheses. In: F. Funk, J.N. Ianelli, T.J. Quinn II, and P.J. Sullivan (eds.) Proceedings of the international symposium on fishery stock assessment models for the 21st century. Alaska Sea Grant College Program.

Dean, T.A., J.L. Bodkin, S.C. Jewett, D.H. Monson and D. Jung. 2000. Changes in sea urchins and kelp following a reduction in sea otter density as a result of the *Exxon Valdez* oil spill. Marine Ecology Progress Series. 199:281-291.

Bodkin, J.L. 2000. Sea otters past and present perspectives. Alaska Geographic. 7(2):73-93.

Monson, D.H., D.F. Doak, B.E. Ballachey, A. Johnson, and J.L. Bodkin. 2000. Long-term impacts of the *Exxon Valdez* oil spill on sea otters, assessed through age-dependent mortality patterns. Proceedings National Academy of Sciences, USA.97(12):6562-6567.

Bodkin, J.L. 2001. Marine Mammals: Sea otters. Pages 2614-2621. in Steele, J. S.Thorpe and K. Turekian (eds.) Encyclopedia of Ocean Sciences. Academic Press, London UK. (invited ms)

Gorbics, C and J.L. Bodkin. 2001. Stock Identity of sea otters in Alaska. Marine Mammal Science 17(3):632-647.

Dean, T.A., J.L. Bodkin, A.K. Fukuyama, S.C. Jewett, D.H. Monson, C.E. O'Clair, and G.R. VanBlaricom. 2002. Food limitation and the recovery of sea otters in Prince William Sound. Marine Ecology Progress Series. 241:255-270.

Bodkin, J.L., B.E. Ballachey, T.A. Dean, A.K. Fukuyama, S.C. Jewett, L.M. McDonald, D.H.Monson, C.E. O'Clair and G.R. VanBlaricom. 2002. Sea otter population status and the process of recovery from the Exxon Valdez oil spill. Marine Ecology Progress Series. 241:237-253.

Estes, J.A. and J.L. Bodkin. 2002. Marine Otters. In W.F. Perrin, B. Wursig,, J.G.M. Thewissen and C.R. Crumly (eds) Encyclopedia of Marine Mammals. Academic Press 843-858. (invited ms).

Larson, S., R.J. Jameson, J.L. Bodkin, M. Staedler and P. Bentzen. 2002. Microsatellite and MTDNA sequence variation within and among remnant, source and translocated sea otter (Enhydra lutris) populations. J. Mammalogy 83(3):893-906.

Bodkin, J.L. and D.H. Monson. 2002. Sea otter population structure and ecology in Alaska. Arctic Research. 16:31-35

Baskaran, M., G.-H. Hong, S. Dayton, J.L. Bodkin, and J.J. Kelly. 2003. Temporal variations of natural and anthropogenic radionuclides in sea otter skull tissue in the North Pacific Ocean. J. Env. Radioactivity 64:1-18.

Bodkin, J.L. 2003. Return to Glacier Bay. Alaska Park Science, National Park Service, Anchorage, AK pages 4-11

Peterson, C.H., S.D. Rice, J.W. Short, D. Esler, J.L. Bodkin, B.E. Ballachey, D.B. Irons. 2003. Long-term ecosystem response to the Exxon Valdez oil spill. Science 302:2082-2086.

Ballachey, B.E., J.L. Bodkin, S. Howlin, A.M. Doroff, and A.H. Rebar. 2003. Correlates to survival of juvenile sea otters in Prince William Sound, Alaska. Canadian J. Zoology 81:1494-1510.

Bodkin, J.L. 2003. Sea Otter. Pages 735-743, in Feldham. G. A., B.C. Thompson, and J.A. Chapman (eds), Wild Mammals of North America, 2nd edition. Johns Hopkins University Press, Baltimore. 735-743. (invited ms).

Bodkin, J.L., G.G. Esslinger and D.H. Monson. 2004. Foraging depths of sea otters and implications to coastal marine communities. Marine Mammal Science 20(2):305-321.

Bodkin, J.L. 2004. Status of sea otter populations in south central and southeast Alaska, 2002-2003. Pages 12-13 *in* D. Maldini, D. Calkins, S. Atkinson, and R. Meehan, eds. Alaska Sea Otter Workshop: Addressing the decline of the southwestern Alaska sea otter population. Alaska Sea Grant College Program, University of Alaska, Fairbanks, AK, pp 12-13.

Bodkin, J.L. 2004. Sea otter research and tools. Alaska Sea Otter Workshop: Addressing the decline of the southwestern Alaska sea otter population. Pages 47-49 *in* D. Maldini, D. Calkins, S. Atkinson, and R. Meehan, eds. Alaska Sea Otter Workshop: Addressing the decline of the southwestern Alaska sea otter population. Alaska Sea Grant College Program, University of Alaska, Fairbanks, AK

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Monson, D.H., J.L. Bodkin, D.F. Doak, J.A. Estes, M.T. Tinker, and D.B. Siniff. 2004. Population demographics, survival, and reproduction: Alaska sea otter research. Pages 60-65 *in* D. Maldini, D. Calkins, S. Atkinson, and R. Meehan, eds. Alaska Sea Otter Workshop: Addressing the decline of the southwestern Alaska sea otter population. Alaska Sea Grant College Program, University of Alaska, Fairbanks, AK

Lowry, L.L. and J.L. Bodkin. 2005. Marine Mammals, in. Phillip R. Mundy (ed.). The Gulf of Alaska: Biology and Oceanography. Alaska Sea Grant College Program, University of Alaska Fairbanks. pp 99-116

Scribner, K.T. B.A. Green, C. Gorbics, and J.L. Bodkin. 2005. Verification of field-reported sex from harvested sea otters using DNA testing. Wildlife Society Bulletin 33(3):1-6.

Laidre, K.L., J. A. Estes, M. T. Tinker, J. Bodkin, D. Monson, and K. Schneider. 2006. Patterns of growth and body condition in sea otters from the Aleutian archipelago before and after the recent population decline. J. Animal Ecology 75:978-989.

Tinker, T.M., D.F. Doak, J.A. Estes, B.H. Hatfield, M.M. Staedler, J.L. Bodkin. 2006. Incorporating diverse data and realistic complexity into demographic estimation procedures: a case study using the California sea otter, *Enhydra lutris nereis*. Ecological Applications 16(6):2293-2312.

Iverson, S.J., A.M. Springer, and J.L. Bodkin 2007. Strategies for survival: Marine Mammals. Pages 114-131, *in* Robert Spies (ed.). Long term ecosystem change in the northern Gulf of Alaska. Elsevier, Amsterdam, the Netherlands.

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Bodkin, J.L. and M. Kenner. 1988. A preliminary report on the demography of the spiny lobster, Panulirus interruptus, at San Nicolas Island, CA. Mugu Lagoon/San Nicolas Island Research Symposium, Pt. Mugu, CA. November, 1988.

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Research Wildlife Biologist, Alaska Science Center, 1996-present
Biological Technician and Statistical Assistant, Alaska Science Center, 1987-1996
2009 – Ph.D., University of California Santa Cruz, Santa Cruz, CA. (Ecol. & Evol. Biology)
1995 – M.S., University of California Santa Cruz, Santa Cruz, CA. (Marine Science)
1983 – B.A., Luther College, Decorah, Iowa (Biology)

I have worked within the Coastal Ecosystems research program for the Alaska Science Center since 1987 where I have three decades of experience conducting multi-disciplinary research on sea otters and their nearshore environment with collaborators from more than a dozen different agencies, academic and private institutions. I have focused on developing metrics of sea otter population status, which can provide important insights into the health and function of nearshore systems. Beginning in 2012, I became a PI for the Nearshore component within the GulfWatch Program where my role is to conduct high quality research focused on understanding natural and anthropogenic factors affecting nearshore ecosystems that will be critical for ecosystem-based management of these resources.

Relevant Publications

Chinn, S. M., D. H. Monson, M.T. Tinker, M. M. Staedler, and D. E. Crocker. 2018. Lactation and Resource Limitation Affect Stress Responses, Thyroid Hormones, Immune Function and Antioxidant Capacity of Sea Otters (*Enhydra lutris*). Integrative and Comparative Biology. 58:E37.

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Bodkin, J.L., G.G. Esslinger, and D.H. Monson. 2004. Foraging depths of sea otters and implications to coastal marine communities. Mar. Mamm. Sci. 20:305-321.

Bodkin, J.L., B.E. Ballachey, T.A. Dean, A.K. Fukuyama, S.C. Jewett, L. McDonald, D.H. Monson, C.E. O'Clair, and G.R. VanBlaricom. 2002. Sea otter population status and the process of recovery from the 1989 'Exxon Valdez' oil spill. Marine Ecology Progress 241:237-253.

Dean, T.A., J.L. Bodkin, A.K. Fukuyama, S.C. Jewett, D.H. Monson, C.E. O'Clair, and G.R. VanBlaricom. 2002. Food limitation and the recovery of sea otters following the 'Exxon Valdez' oil spill. Marine Ecology Progress Series. 241:255-270.

Monson, D.H., C. McCormick, and B.E. Ballachey. 2001. Chemical anesthesia of northern sea otters (*Enhydra lutris*): Results of past field studies. J. Zoo Wildl. Medicine 32:181-189.

Monson, D.H., D.F. Doak, B.E. Ballachey, A. Johnson, and J.L. Bodkin. 2000. Long-term impacts of the *Exxon Valdez* oil spill on sea otters, assessed through age-dependent mortality patterns. Proceedings of the National Academy of Sciences. 97:6562-6567.

Monson, D.H., J. A. Estes, J.L. Bodkin, and D.B. Siniff. 2000. Life history plasticity and population regulation in sea otters. Oikos 90:457-468.

Dean, T.A., J.L. Bodkin, S.C. Jewett, D.H. Monson, and D. Jung. 2000. Changes in sea urchins and kelp following a reduction in sea otter density as a result of the *Exxon Valdez* oil spill. Marine Ecology Progress Series 199:281-291.

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DeGange, A.R., A.M. Doroff, and D.H. Monson. 1994. Experimental recovery of sea otter carcasses at Kodiak Island, Alaska, following the *Exxon Valdez* oil spill. Mar. Mamm. Sci. 10:492-496.

CURRICULUM VITAE
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Education

2011 - Master of Science, Biological Sciences, University of Alaska, Anchorage, AK
1993 - Bachelor of Science, Wildlife, Humboldt State University, Arcata, CA

Work experience

11/98 – present	Zoologist, U.S. Geological Survey, Anchorage, AK
10/96 – 11/98	Fish and Wildlife Biologist, U.S. Geological Survey, Anchorage, AK
04/95 – 10/96	Fish and Wildlife Biologist, U.S. Fish and Wildlife Service, Anchorage, AK
04/93 – 04/95	Biological Science Technician, U.S. Fish and Wildlife Service, Anchorage, AK

Professional licenses and memberships

Member, USGS Diving Safety Board, 2010-present, Anchorage, AK
Research Vessel Manager, U.S. Geological Survey, 2006-present, Anchorage, AK
Oxygen Rebreather Diver, Aqua Lung, 2006, Vista, CA
Master 50-100 ton License, U.S. Coast Guard, 1999-present, Anchorage, AK
Motorboat Operator Instructor, Department of Interior, 1997, Lake Mead, NV
Divemaster, NOAA Dive Program, 1996, Seattle, WA
Working Diver, NOAA Dive Program, 1994, Seattle, WA

Publications

Tinker, MT, V Gill, GG Esslinger, JL Bodkin, M Monk, M Mangel, DH Monson, WW Raymond, M Kissling. In Press. Trends and carrying capacity of sea otters in southeast Alaska. Journal of Wildlife Management.

Williams, PJ, MB Hooten, GG Esslinger, JN Womble, JL Bodkin, and MR Bower. 2019. The rise of an apex predator following deglaciation. Diversity and Distributions 25.

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Williams, PJ, MB Hooten, JN Womble, GG Esslinger, and MR Bower. 2018. Monitoring dynamic spatio-temporal ecological processes optimally. Ecology 99:524-535.

Williams, PJ, MB Hooten, JN Womble, GG Esslinger, M Bower, & TJ Hefley. 2017. An integrated data model to estimate spatio-temporal occupancy, abundance, and colonization dynamics. Ecology 98:328–336.

Esslinger, G.G., D. Esler, S. Howlin, and L.A. Starcevich. 2015. Monitoring population status of sea otters (*Enhydra lutris*) in Glacier Bay National Park and Preserve, Alaska—Options and considerations. U.S. Geological Survey Open-File Report 2015-1119, 42 p., http://dx.doi.org/10.3133/ofr20151119.

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Esslinger, G. G. 2011. Temporal patterns in the behavior and body temperature of sea otters in Alaska. M.S. Thesis, Department of Biological Sciences, University of Alaska, Anchorage. 74 pp.

Jewett, S. C., J. L. Bodkin, H. Chenelot, G. G. Esslinger, and M. K. Hoberg. 2010. The Nearshore Benthic Community of Kasatochi Island, One Year after the 2008 Volcanic Eruption. Arctic, Antarctic, and Alpine Research 42(3):315-324. DOI:10.1657/1938-4246-42.3.315

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Bodkin, JL, KA Kloecker, GG Esslinger, DH Monson, JD DeGroot, and J Doherty. 2002. Sea otter studies in Glacier Bay National Park and Preserve. Annual Report 2001. USGS Alaska Science Center, Anchorage, AK.

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Presentations

Esslinger, GG. 2018. A sea otter aerial survey method that adjusts for detection. 2018 Sea Otter Survey Meeting – New Ideas, New Directions, Santa Cruz, CA, 21 March 2018.

Esslinger, GG, D Esler, KA Kloecker, DH Monson, B Robinson, BP Weitzman. 2018. Current research on sea otters in Alaska by the Nearshore Marine Ecosystem Research Program. Southern Sea Otter Research Update Meeting, Santa Cruz, CA, 20 March 2018.

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Esslinger, GG. 2017. Sea otter survey efforts and priorities for the U.S. Geological Survey. Sea otter population monitoring in Alaska – An Inter-agency Meeting, Anchorage, AK, 8-9 November 2017.

Tinker, MT, W Raymond, JL Bodkin, GG Esslinger, DH Monson, BP Weitzman, V Gill, Z Hoyt, G Eckert, B Benter, and M Kissling. 2017. Spatial variation in harvest mortality and density dependent processes drive patterns of sea otter recovery in Southeast Alaska. Marine Mammal Conference, Halifax, Nova Scotia, Canada, 22-27 October 2017.

Esslinger GG, HA Coletti, JL Bodkin, DH Monson, BE Ballachey, TA Dean, and D Esler. 2017. Contrasting demography and behavior of sea otter populations in the northern Gulf of Alaska. Alaska Chapter of the Wildlife Society Annual Meeting, 5-6 April 2017, Fairbanks, AK.

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Williams, PJ, MB Hooten, MR Bower, JN Womble, and GG Esslinger. 2016. A Spatio-Temporal Model to Infer Colonization Dynamics, and Inform Monitoring of Sea Otters in Glacier Bay, Alaska. The Wildlife Society, Oct 15-19, 2016 Raleigh, NC.

Monson, DH 2015. Sea Otter Conservation Workshop, 27-29 Mar 2015, Seattle, Washington.

Weitzman, BP 2015. Sea Otter Conservation Workshop, 27-29 Mar 2015, Seattle, Washington.

Esslinger, G.G., B.P. Weitzman, J.L. Bodkin, K.A. Kloecker, M.T. Tinker, and J.A. Estes. 2014. Dietary patterns associated with the recolonization of sea otters in Glacier Bay. 2014 Juneau Sea Otter Conference, May 20, 2014. Juneau Center, School of Fisheries and Ocean Sciences University of Alaska Fairbanks, Juneau, Alaska. [INVITED]

Esslinger, G.G., B.P. Weitzman, J.L. Bodkin, K.A. Kloecker, M.T. Tinker, and J.A. Estes. 2014. Dietary patterns associated with the recolonization of sea otters in Glacier Bay, May 22, 2014. 2014 Prince of Wales Island Sea Otter Meeting, Klawock, Alaska. [INVITED]

Esler, D., J. Bodkin, B. Ballachey, D. Monson, G. Esslinger, K. Kloecker, S. Iverson, K. Miles, and L. Bowen. 2014. 25 years after the Exxon Valdez oil spill: recovery timelines of harlequin duck and sea otter populations. Alaska Marine Science Symposium, Anchorage, AK.

Esslinger, G.G. , B.P. Weitzman, J.L. Bodkin, K.A. Kloecker, M.T. Tinker, and J.A. Estes. 2013. Understanding the impacts of sea otters on invertebrates in Glacier Bay. The science of Southeast Alaska's sea otters: A symposium to share the latest scientific data. University of Alaska Southeast, Juneau, Alaska. [INVITED]

Weitzman, B.P., J.L. Bodkin, G.G. Esslinger, K.A. Kloecker, M.T. Tinker, and J.A. Estes. 2013. Colonization in action: understanding the impacts of sea otters on soft-sediment invertebrate communities. Alaska Marine Science Symposium, Anchorage, AK.

Esslinger, G.G., J. L. Bodkin, and J. M. Burns. 2011. Temporal variation in the body temperature of sea otters in Alaska. Sea Otter Conservation Workshop VII, 25-27 Mar 2011, Seattle, Washington.

Esslinger, G.G. Sea Otters in Glacier Bay National Park and Preserve. Presentation to Glacier Bay interpretive rangers and other staff. Glacier Bay National Park & Preserve, Gustavus, AK. April 2010. [INVITED]

Weitzman, B. P, J. L. Bodkin, G. G. Esslinger, K. A. Kloecker, M. T. Tinker, J. A. Estes. 2010. The effects of sea otter recolonization on benthic intertidal invertebrate communities in Glacier Bay, Alaska. Western Society of Naturalists, Nov 11-14, San Diego, CA.

Esslinger, G. G., J. M. Burns, D. H. Monson, J. L. Bodkin, A. R. Breton. 2009. Temporal patterns in the foraging behavior of sea otters in Prince William Sound, Alaska. Sea Otter Conservation Workshop, 20-22 Mar 2009, Seattle, Washington.

Esslinger, G. G., J. M. Burns, D. H. Monson, J. L. Bodkin, A. R. Breton. 2009. Archival time-depth data reveal seasonal variation in sea otter foraging behavior. Carnivore Conference, Nov 15-18, 2009, Denver, Colorado.

Tinker, M.T., Bodkin, J., Staedler, M., Esslinger, G., Monson, D., Bentall, G., Murray, M. 2008. Using TDR records to detect reproductive events in sea otters. Third International Biologging Science Symposium, September 1-5, 2008, Pacific Grove, CA.

Esslinger, G. G., and J. L. Bodkin. Sea otter surveys and population models. Sitka Tribe of Alaska, Marine Mammal Commission, Sitka, AK, 8-10 Feb 2006.

Bodkin, J. L., B. E. Ballachey, G. G. Esslinger, K. A. Kloecker, D. H. Monson, and H. A. Coletti. 2004. Perspectives from an invading predator: Sea otters in Glacier Bay. Glacier Bay Science Symposium 25-29 October, Juneau, AK.

Haverlack, S. G., J. L. Bodkin, G. G. Esslinger, B. P. Kelly, and D. H. Monson. 2001. Discriminating foraging dives from traveling dives of sea otters. 14th Biennial meeting of the Society for Marine Mammalogy, 28 Nov-3 Dec. 2001. Vancouver, Canada.

Bodkin, J. L., G. G. Esslinger, and D. H. Monson. 2000. Diving behavior of sea otters in southeast Alaska. Seventh Joint US-Russia sea otter workshop. 14-16 November, 2000, Monterey, CA. Abstract.

Bodkin, J. L, K. A. Kloecker, G. G. Esslinger, and D. H. Monson. 2000. Observations of sea otter foraging behavior, estimated population size, and intertidal clam and urchin abundance, density and size class distribution in Glacier Bay National Park, AK. Seventh Joint US-Russia sea otter workshop. 14-16 November, 2000, Monterey, CA. Abstract.

Bodkin, J. L., B. P. Kelly, and G.G. Esslinger. 1998. Sea otter diving depths and implications to fisheries. World Marine Mammal Conference, Monaco. 20-25 January, 1998. Abstract.

Bodkin, J. L., B. P Kelly, and G.G. Esslinger. 1997. Monitoring sea otter dives with ultra-sonic transmitters and time-depth recorders. 6th Joint Russia/U.S. sea otter workshop. 15-19 November, 1997, Forks, WA. Abstract.

Bodkin, J. L. and G. G. Esslinger. 1995. Accuracy and precision in estimating ages of sea otters using cementum layers in the first premolar. 8th Northern Furbearer Conference. Anchorage, Alaska. 3-5 May 1995. Abstract.

Posters

Coletti, H.A., D. Esler, B.E. Ballachey, J.L. Bodkin, T.A. Dean, G.G. Esslinger, K. Iken, K.A. Kloecker, B. Konar, M. Lindeberg, D.H. Monson, and B. Weitzman. 2016. Long-term monitoring of nearshore marine ecosystems in the Gulf of Alaska: Detecting change and understanding cause. Alaska Marine Science Symposium, Anchorage, AK.

Weitzman, B.P., G.G. Esslinger, J.L. Bodkin, K.A. Kloecker, , D.H. Monson, M.T. Tinker, and J.A. Estes. 2015. Implications of recolonization and food limitation for sea otters in soft-bottom habitats of Glacier Bay, AK. Alaska Marine Science Symposium, Anchorage, AK.

Ballachey, B., L. Bowen, K. Miles, G. Esslinger, M. Lindeberg, K. Kloecker, and H. Coletti. 2014. Gene transcript profiles in mussels (*Mytilus trossulus*) from Prince William Sound, Alaska, 2012 & 2013, as indicators of nearshore ecosystem health. Alaska Marine Science Symposium, Anchorage, AK.

Awards

U.S. Geological Survey Occupational Health and Safety Award of Merit – 2010
Department of the Interior Occupational Health and Safety Award of Excellence– 2010

Animal capture and handling experience

Captured >500 sea otters using dive gear in Alaska, California, and British Columbia
Captured and handled >1,000 sea otters using tangle nets in Alaska, California, and British Columbia
Captured and handled Steller sea lions, harbor seals, harbor porpoises, mule deer, marine birds, shorebirds, fresh and saltwater fishes, and marine invertebrates.

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EDUCATION:

B.A., University of Minnesota, 1967. Zoology/Chemistry
M.S., Washington State University, 1970. Zoology
Ph.D., University of Arizona, 1974. Biology/Statistics

CURRENT MEMBERSHIP IN PROFESSIONAL SOCIETIES

American Association for the Advancement of Science
Ecological Society of America
Society for Conservation Biology
Society for Marine Mammalogy

PROFESSIONAL AWARDS

Sigma Xi, 1969
Phi Kappa Phi, 1969
American Men and Women of Science, 1978
Outstanding publication, US Fish and Wildlife Service, 1978
Outstanding publication, US Fish and Wildlife Service, 1981
Betty S. Davis Conservation Award, 1987
Distinguished Alumnus Award and Lecture, University of Arizona, 1990
Exceptional Service Award, Department of the Interior, 1990
Eugene M. Schoemaker Award for Distinguished Achievement in Communication, US Geological Survey, 1997
Pew Fellow in Marine Conservation, 1999
Fellow, California Academy of Science, 1999
Meritorious Service Award, US Geological Survey, 2003
Ed Ricketts Award and Lecture, Monterey Bay National Marine Sanctuary, 2004
Director's Award, US Geological Survey, 2004
Lifetime Achievement Award, Western Society of Naturalists, 2011
C. Hart Merriam Award, American Society of Mammalogists, 2012
US National Academy of Sciences, 2014

COMMITTEES AND SERVICE

Standing Committee on Marine Mammals, American Society of Mammalogists, 1978-1982, co-chairman, 1979-1982.

Steering/Planning Committee, Marine Mammal Subgroup, US/USSR Program for Conservation of the Environment, 1976-1979.

Workshop on mammals in the sea, Bergen, Norway, "Unit ecosystems working group report", 1976. Session Chair

Otter Specialist Group, Species Survival Commission, International Union for the Conservation of Nature, 1977-present, Deputy Chairman, 1981.

Workshop on social science perspectives on managing conflicts between marine mammals and fisheries, Arroyo Grande, California. Biological problems panel member, 1981.

Third International Otter Colloquium, Santa Cruz, California, 1985, Organizing Committee

Symposium on the community ecology of sea otters, Western Society of Naturalists, Monterey, California, "Sea otters, sea urchins, and kelp beds: some questions of scale", 1985. Co-organizer of symposium with G.R. VanBlaricom.

Pacific Rim development committee. University of California, Santa Cruz, 1985-1986.

International Asian Otter Symposium. Proceedings Editor, 1988.

Southern Sea Otter Recovery Team Member, US Fish and Wildlife Service, 1989-2000

Joint U.S./Russian sea otter workshop, Wasilla, Alaska. 1993, Session Chair

Board of Editors, *Ecology/Ecological Monographs*, 1993-95

Strategic Planning Workshop for National Biological Service, Washington, D.C., 1995.

Board of Editors, *Animal Conservation*, 1997-2001

Vision Workshop for research on ocean ecology. Hosted by National Science Foundation. 1998.

Science Advisory Committee, National Center for Ecological Analysis and Synthesis, National Science Foundation, 1999-2002

Committee member, NRC, National Academy of Sciences, *Relationships between fisheries and Steller sea lions*, 2001-2002.

Board of Editors, *Frontiers in Ecology and the Environment*, 2003-2007

Editor-in-Chief, *Marine Mammal Science*, 2005-2008

Member Recovery Team, Southwest Alaska Sea Otter, 2005-2010

Board of Governors, Wildland Network, 2010-present

Steering Committee, 2011 Mote Fisheries Symposium

Steering Committee, Yale Climate and Energy Conference: Managing Species for Regulating the Carbon Cycle, 2012

Board of Editors, *Proceedings of the National Academy of Sciences*, 2015-

Committee member, NRC, National Academy of Sciences, *Multiple Stressors on Marine Mammals,* 2015-2016.

Member, Ocean Studies Board, National Research Council, 2016-

Editorial Board, *Annual Review of Ecology Evolution and Systematics*, 2018 -

CONTRACTS AND GRANTS

1964-1965. National Defense and Education Association, Graduate Research Fellowship, Washington State University

1967. National Science Foundation, Summer Traineeship, Washington State University

1970-1972. (with N.S. Smith) Energy Research and Development Administration, Research on sea otters at Amchitka Island, Alaska[redacted])

1984-1985. (with G.R. VanBlaricom) National Geographic Society, Interactions between sea otters and intertidal mussel populations in Prince William Sound, Alaska ([redacted]

1985. (with M. Riedman) The Banbury Foundation, Behavior and population biology of sea otters near Monterey Bay, California [redacted])

1985-1987. (with D.O. Duggins and C.A. Simenstad) National Science Foundation, Sea otters, alternative communities, and the role of kelp-derived carbon in nearshore food webs ([redacted])

1986. (with M. Riedman) The Banbury Foundation, Behavior and population biology of sea otters near Monterey Bay, California ([redacted]

1986-1987. (with D.O. Duggins and C.A. Simenstad) National Science Foundation, The impact of sea otters on nearshore food webs and the role of kelp-derived carbon in coastal ecosystems: secondary production supplement ([redacted])

1987-1988. (with J.S. Pearse) City of Santa Cruz, Study of the behavior and population biology of sea otters in relation to activities associated with construction of the Santa Cruz Sewage Outfall [redacted]

1990-1992. (with P.D. Steinberg) National Science Foundation, Geographical variation in the effects of brown algal secondary metabolites on temperate marine herbivores [redacted])

1991-1993. (with D.B. Siniff) National Science Foundation, The behavioral ecology of sea otters at Amchitka Island, Alaska ([redacted]

1995. Legacy Program, U.S. Navy, The behavioral ecology of sea otters at Adak Island, Alaska. [redacted]

1995-97. Legacy Program, U.S. Air Force, The ecology of sea otters and coastal marine communities at Shemya Island, Alaska. ([redacted])

1996-97. (with W. Jarman) U.S. Navy, Contaminant levels in blue mussels in the Aleutian Archipelago. ($[redacted]

1997-1999. (with W. Jarman) U.S. Navy, Spatial variation in contaminant levels in sea otters based on measurements from blood samples of living animals. [redacted]0).

1999-2002. (with R.G. Anthony, J.R. Bodkin, W. Jarman and A.K. Miles) U.S. Navy. Monitoring program for environmental contaminants in the nearshore marine ecosystem at Adak Island, Alaska. ([redacted]

2000-2004. (with D. Croll and J. Maron) National Science Foundation. Introduced foxes and seabirds: the role of top-down processes in controlling marine subsidies to terrestrial ecosystems. [redacted]

2000-2003. (with T. Williams, D. Costa, K. Ralls, and D. Siniff) Minerals Management Service. Population dynamics and biology of the California Sea Otter at the southern end of its range. [redacted]

2008-2010 (with B. Konar and M. Edwards) National Science Foundation. Kelp forest interaction webs in the Aleutian archipelago: patterns and mechanisms of change following the collapse of an apex predator. ([redacted].

2008-2009 (with J. Bodkin) North Pacific Research Board. Threatened southwest Alaska sea otter stock: delineating the causes and constraints to recovery of a keystone predator in the North Pacific Ocean. [redacted]

2013-2015 (with R. Steneck) National Science Foundation. Ocean acidification: century scale impacts to ecosystem structure and function of Aleutian kelp forests. ([redacted]

INVITED SEMINARS

Institute of Arctic Biology, University of Alaska; Department of Biology, The Pennsylvania State University; Moss Landing Marine Laboratories; Department of Biology, University of California, Santa

Cruz; Department of Zoology, Oregon State University; Department of Biology, Sacramento State University; Denver Wildlife Research Center; National Marine Mammal Laboratory, Seattle; Museum of Vertebrate Zoology, University of California, Berkeley; Department of Zoology, University of Washington; Department of Biology, University of Victoria; Division of Natural Sciences, University of Victoria; Hopkins Marine Station, Stanford University; Scripps Institution of Oceanography; Department of Fisheries and Wildlife, Oregon State University; Department of Paleontology, University of California, Berkeley; Department of Biology, San Diego State University; Institute of Marine Sciences, University of North Carolina; Duke University Marine Laboratory; Institute of Marine Sciences, State University of New York at Stony Brook; Department of Ecology and Behavioral Biology, University of Minnesota; Department of Zoology, University of Auckland; Leigh Marine Laboratory, University of Auckland; Department of Renewable Natural Resources, University of Arizona; Department of Biology, Stanislaus State University; Bodega Marine Laboratory, University of California; Department of Biological Sciences, University of California at Santa Barbara; Santa Cruz Natural History Society; National Ecology Research Center; Alaska Fisheries and Wildlife Research Center; University of California at Davis; Institute of Ecosystem Studies, Millbrook, New York (2 seminars); Department of Integrative Biology, University of California, Berkeley; Department of Biology, University of Nevada, Reno; Department of Biology, University of Durham, UK; Department of Biology, Boise State University; Department of Wildlife Biology, University of Montana; Department of Biology, UCLA; Universidad Católica, Santiago, Chile; Valpariso University, Valpariso, Chile; Georgia Tech University; Darling Marine Center, University of Maine; Department of Biology, University of Pennsylvania; Department of Ecology and Evolutionary Biology, University of Minnesota; Department of Biology, University of Denver; Marine Sciences Center, University of Texas, Port Aransas; Humboldt State University; NOAA Fishery Science Center, Seattle; Stanford Law School; Duke University Marine Laboratory, Beaufort, North Carolina; Institute of Marine Sciences, University of Alaska, Fairbanks; Department of Biology, University of Alaska, Juneau; University of California, Bodega Marine Laboratory; Department of Fisheries and Wildlife, Oregon State University; Department of Biology, San Diego State University; Department of Fisheries and Wildlife, Iowa State University; Department of Biology, Georgia Institute of Technology; Department of Ecology and Evolution, Cornell University; Department of Fisheries and Wildlife, Cornell University; Marine Biology Laboratory, Woods Hole Oceanographic Institution; Department of Natural Resources, University of California Berkeley; Department of Biology, University of Wyoming; Department of Biology, Chapman College; Department of Fisheries and Wildlife, Oregon State University; The American Museum of Natural History, New York City; The Wildlife Conservation Society, Bronx Zoo; University of Nevada, Reno; Moss Landing Marine Laboratories; University of California, Berkeley; Georgia Tech University; University of Florida; Princeton University; University of Pennsylvania; State University of New York, Stony Brook; Scripps Institution of Oceanography; California State University, Northridge; University of British Columbia; CCIMAR, La Paz, Mexico; Santa Barbara City College; University of Maine; Hopkins Marine Station, Stanford University; Utah State University; University of Alaska; University of New Mexico; University of California, Los Angeles; Colorado State University; University of California, Santa Barbara; University of Nebraska; Moss Landing Marine Laboratories; Kansas State University; Institute of Ecosystem Studies ; University of Wisconsin ; University of Idaho; Oregon State University; Princeton University; West Chester University; University of Victoria; Simon Fraser University; Yale University

TEACHING

1984-1997. Probability, sampling and experimental design. University of California, Santa Cruz

1985. Stability in ecological systems. Graduate level seminar course, University of California, Santa Cruz

1987. Plant/Herbivore Interactions: marine-terrestrial comparisons. Graduate Seminar Course, University of California, Santa Cruz.

1989. Community Ecology (Diamond and Case, eds). Graduate Seminar, University of California, Santa Cruz

1997. Experiments in Ecology (A.J. Underwood). Graduate Seminar, University of California, Santa Cruz

1998. Method in Ecology (Shrader-Frechette and McCoy). Graduate Seminar Course, University of California, Santa Cruz

2000. Design of protected areas on land and in the sea. Graduate Seminar, University of California, Santa Cruz

2010-present. General Ecology. University of California, Santa Cruz

2010. Trophic Cascades. (Terborgh and Estes). Graduate Seminar, University of California, Santa Cruz

2011. General Ecology. University of California, Santa Cruz

2012. General Ecology. University of California, Santa Cruz

2013. General Ecology. University of California, Santa Cruz

2014. Controversies in conservation, graduate seminar, UC Santa Cruz; Graduate training course, UC Santa Cruz (2014 to present)

2017 Graduate student training course, preparation for Qualify Examination, UC Santa Cruz

GRADUATE STUDENTS SUPERVISED

James P. Thompson, M.S., 1982. Thesis title, "Benthic illumination within a Macrocystis bed at Pt. Soquel, Santa Cruz, California, and its influence upon Macrocystis population structure and the abundance of benthic red algae". Institute of Marine Sciences, University of California, Santa Cruz.

Cynthia Zabel, Ph.D., 1986. Dissertation title, "Reproductive behavior of the red fox (*Vulpes vulpes*): a longitudinal study of an island population". Department of Biology, University of California, Santa Cruz.

Spencer James Taggart, Ph.D., 1987. Dissertation title, "Grouping behavior of Pacific walruses (*Odobenus rosmarus divergens* Illiger), an evolutionary perspective". Department of Biology, University of California, Santa Cruz.

Claire Michaels, M.S., 1988. Thesis title, "Foraging and habitat use by the herbivorous shore crab, *Pachygrapsus crassipes*, at San Nicolas Island, California". Institute of Marine Sciences, University of California, Santa Cruz.

Carolyn B. Heath, Ph.D. 1989. Dissertation title, "The behavioral ecology of the California sea lion (*Zalophus californianus*)". Department of Biology, University of California, Santa Cruz.

Kathy J. Lyons, Ph.D. 1991. Thesis title, "Foraging behavior of California sea otters: the importance of individual variation". Institute of Marine Sciences, University of California, Santa Cruz.

Frank Winter, M.S. 1991. Thesis title, "Polyphenolics from the kelp *Dictyoneurum californicum* deter grazing by the red abalone, *Haliotis rufescens*". Institute of Marine Sciences, University of California, Santa Cruz.

Jane Watson, Ph.D. 1993. Dissertation title, "Predation and the ecology of kelp forest communities in British Columbia". Department of Biology, University of California, Santa Cruz.

Diane Carney, M.S. 1991. Thesis title, "Behavior, ecology, and reproduction of red sea urchins in Sitka Sound, Alaska". Institute of Marine Sciences, University of California, Santa Cruz.

Breck Tyler, M.S. 1991. Thesis title, "Behavioral ecology of tropicbirds in the northwest Hawaiian Islands". Institute of Marine Sciences, University of California, Santa Cruz.

Laura McShane, M.S. 1991. Thesis title, "A spectrographic analysis of vocalization in the sea otter". Institute of Marine Sciences, University of California, Santa Cruz.

Maria Sanchez, M.S. 1992. Thesis title, "Geographical variation in sea otters based on mitochondrial DNA". Institute of Marine Sciences, University of California, Santa Cruz.

Corinne Bacon, M.S. 1994. Thesis title, "An ecotoxicological comparison of organic contaminants in sea otters (*Enhydra lutris*) among populations in California and Alaska".

Institute of Marine Sciences, University of California, Santa Cruz.

Daniel H. Monson, M.S. 1995. Thesis title, "Reproductive strategies in sea otters at Amchitka Island, Alaska. Institute of Marine Sciences, University of California, Santa Cruz

Greg Golet, Ph.D. 1999. Dissertation title, "The cost of reproduction in Black Legged Kittiwakes. Institute of Marine Sciences, University of California, Santa Cruz.

Brenda Konar, Ph.D.1998. Dissertation title, "Patterns and mechanisms of succession in subarctic kelp forest communities of the northwest Pacific Ocean". Biology Department, University of California, Santa Cruz.

Steven Lee, M.S. 1995. Thesis title, "Diel activity patterns in sea urchins: an analysis of causality based on biogeographic, taxonomic, and ecological evidence". Institute of Marine Sciences, University of California, Santa Cruz.

Kenneth Vicknair, M.S. 1996. Thesis title, "Sea otters and asteroids in the western Aleutian archipelago". Institute of Marine Sciences, University of California, Santa Cruz.

Michelle Paddack, M.S. 1997. Thesis title, "The importance of refuges to coastal rockfish populations in the Monterey Bay National Marine Sanctuary". Institute of Marine Sciences, University of California, Santa Cruz, CA.

Claire Mathews, M.S. 1996. Thesis title, "Time-energy analyses of sea otter foraging in Monterey Bay, California". Institute of Marine Sciences, University of California, Santa Cruz.

Stacey Lindeman, M.S. 1998. Thesis title, "Evidence for the source of high concentrations of organic contaminants in the Aleutian archipelago based on a spatial analysis of organochlorine levels in blue mussels". Institute of Marine Sciences, University of California, Santa Cruz.

Mathew Edwards, Ph.D. 2001. Dissertation title. “Patterns and mechanism of change in giant kelp forests resulting from the 1997-98 ENSO event”. Department of Ecology and Evolutionary Biology, University of California, Santa Cruz

Shauna Risewietz, M.S. 2002. Thesis title. Shifts in kelp forest fishes and their associated food webs following collapse of sea otter populations in western Alaska. Institute of Marine Sciences, University of California, Santa Cruz

Eric Danner, Ph.D. Dissertation title, “Remote imaging analyses and landscape patterns in island plant communities”. Department of Ecology and Evolutionary Biology, University of California, Santa Cruz

M. Timothy Tinker. Ph.D. Dissertation title. “Behavior and spatial dynamics of the California sea otter population”. Department of Ecology and Evolutionary Biology, University of California, Santa Cruz

Alisha Kage, M.S. 2004, Thesis title, Movement patterns of sea otters. Department of Ecology and Evolutionary Biology, University of California, Santa Cruz.

Gena Bentall, M.S. 2005. Thesis title, Morphological and behavioral correlates of population status in the southern sea otter, *Enhydra lutris nereis:* a comparative study between central California and San Nicolas Island

Hoyt Peckham, Ph.D 2009. Dissertation topic. Behavior, ecology and conservation of loggerhead turtles on the west coast of Baja California, Mexico. Department of Ecology and Evolutionary Biology, University of California, Santa Cruz

Michelle Staedler, M.S. 2011. Thesis title. Behavioral ontogeny of sea otter pups. Department of Ecology and Evolutionary Biology, University of California, Santa Cruz.

Lilian Carswell, M.S. 2010. Thesis title. Population biology of translocated sea otters in southern California. Department of Ecology and Evolutionary Biology, University of California, Santa Cruz.

Erin Dodd, M.S. 2010. Contaminants in California sea otters. Department of Ecology and Evolutionary Biology, University of California, Santa Cruz.

Benjamin Weitzman, M.S. 2012. Thesis title. The recovery of sea otters in Glacier Bay, Alaska Department of Ecology and Evolutionary Biology, University of California, Santa Cruz.

Maxine Tarjan (co-advised with M.T. Tinker). Ph.D. Dissertation in progress. Department of Ecology and Evolutionary Biology, University of California, Santa Cruz

Sarah McKay Strobel (co-advised with M.T. Tinker and C. Reithmuth). Ph.D. Dissertation in progress. Department of Ecology and Evolutionary Biology, University of California, Santa Cruz.

INVITED TALKS AND LECTURES AT SCIENTIFIC MEETINGS

1977. "Research on the sea otter in Alaska". First working meeting of the Otter Specialist Group, IUCN, Paramaribo, Suriname,

1979. "The role of sea otters in coastal community structure". Biennial Meeting of La Sociedad Mexicana para el Estudio de los Mamiferos Marinos, La Paz, Baja California Sur

1980. "Food selection and some foraging tactics of sea otters". International Furbearer Conference, Frostburg, Maryland

1980. Workshop to examine the need for and alternatives to the culling of wild animals, Yarmouth Port, Mass., "The case of the sea otter".

1981. "Las Nutrias del mar, las pesquerias y la organizacion del medio ambiente marino al sur de Punta Concepcion, California". Sociedad Mexicana para el Estudio de los Mamiferos Marinos, La Paz, Baja California Sur

1983. "Sea otters and invertebrate fishery resources: existing and potential conflicts from Canada to Mexico". Workshop on conflicts between marine mammals and fisheries, La Jolla, California.

1987. "Multicausal disturbances and the non-equilibrium structure of a rocky intertidal community at San Nicolas Island, California". California Islands Symposium, Santa Barbara, California

1988. “Research and management of sea otters in the eastern North Pacific Ocean”. International Asian Otter Symposium, Bangalore, India.

1988. “Ecology of extinctions in kelp forest communities”. Annual meeting of the Society for Conservation Biology, Davis, California.

1989. “Sampling and resource assessment in rocky intertidal communities”. Annual Meeting of the Southern California Academy of Sciences, Thousand Oaks, California.

1989. “Population status of the sea otter”. Fifth International Otter Colloquium, Hankensbüttel, Germany.

1989. "Homing behavior of sea otters relocated to San Nicolas Island". International Theriological Congress, Rome, Italy.

1989. “Behavior, ecology and life history of New World otters”. Fifth International Otter Colloquium, Hankensbüttel, Germany.

1991. “Paradigms for managing carnivores: the case of the sea otter”. Zoological Society of London, Symposium, London. INVITED

1992. "The role of plant secondary compounds in marine plant-herbivore interactions: an interhemispheric comparison". Temperate Reef Symposium, Auckland, New Zealand

1992. “Ecology, economics and history: the Pacific maritime fur trade”. Public lecture series for distinguished alumni, University of Arizona.

1993. "The evolutionary consequences of sea otters in kelp forest communities." Joint U.S./Russian sea otter workshop, Wasilla, Alaska

1993. "Environmental contaminants in sea otters." Joint U.S./Russian sea otter workshop, Wasilla, Alaska

1993. “Top-level carnivores and ecosystem effects: questions and approaches”. Cary Conference on *Linking Species and Ecosystems*, Institute of Ecosystem Studies, Milbrook, New York.

1994. “Influences of large, mobile predators in aquatic communities: examples from sea otters and kelp forests”. Royal Society of Scotland, Symposium on predator/prey interactions in aquatic ecosystems, Aberdeen, Scotland. INVITED

1994. "Marine mammals: an overview of research needs in central California." Workshop on the Monterey Bay Research Initiative, University of California, Santa Cruz.

1994. "The search for keystone species". Workshop on keystone species, UNEP Global Biodiversity Assessment, Hilo, Hawaii.

1995. “Sea otters as a keystone species”. Plenary lecture, Annual meeting of the Wildlife Society, Portland, Oregon.

1995. "Careers in conservation." Western Regional Meeting of AAAS/Society for Conservation Biology.

1996. "The NBS research program on sea otters". California Biodiversity initiative, Monterey Bay National Marine Sanctuary.

1996. "Comparative demography of sea otter populations". Workshop on the sea otter, Endangered Species Update, Monterey Bay Aquarium.

1997. “Sea otters as umbrella species in the conservation of kelp forest ecosystems”. Symposium on species and ecosystem approaches to management. Annual Meeting of the Society for Conservation Biology, Victoria, British Columbia.

1997. “Catastrophic declines in sea otter populations in the Aleutian archipelago”. Monterey Bay Biodiversity Symposium, Santa Cruz, CA.

1997. “Do sea otters make a good umbrella species for the conservation of kelp forest ecosystems?” International Theriological Congress, Acapulco, Mexico.

1997. “Why rehabilitate oiled wildlife?” 5th International symposium on wildlife and oil spills. Monterey, California, 3-5 November 1997.

1998. “Why predators matter”. Keynote Lecture. Grass roots meeting of the Wildlands Project, Estes Park. Colorado.

1998. “Sea otters and kelp forests”. Public lecture series of the US Geological Survey, Menlo Park.

1999. “Predators and ecosystems”. Sigma Xi Lecture, University of California, Santa Cruz.

2000. “Predation in the sea”. Inaugural Lecture of the Seymour Marine Discovery Center, University of California, Santa Cruz.

2000. “Apex predators and trophic cascades in some marine and terrestrial ecosystems”. Society for Conservation Biology Annual Meeting, Missoula, Montana.

2000. “Apex predators, ecosystem connectivity, and the optimal size of marine reserves”. Plenary Lecture, American Fisheries Society, Fairbanks.

1999. “Status of sea otters in the Aleutian Islands”. US/Russia joint sea otter meeting, Monterey.

2001. “Tales of past abundance: an Alaskan story”. Colloquium on Marine Conservation, Monterey Bay Aquarium.

2001. “Predators and ‘the balance of nature’”. Schweppe Public Lecture Series in marine sciences, University of Texas, Port Aransas, Texas.

2001. “Predators and the balance of nature”. Distinguished Marine Scientist Colloquium, Hatfield Marine Sciences Center, NOAA and Oregon State University.

2001. “Predators and the balance of nature”. Peter Leveque Natural History Lecture, Santa Rosa Junior College.

2001. “Chain reactions in kelp forests: long ago and far away”. American Association for the Advancement of Science, Annual Meeting.

2002. “Complex interactions in kelp forest ecosystems”. Plenary Lecture, *Carnivores 2002*, Conference sponsored by Defenders of Wildlife, Monterey, California.

2002. “Process advocacy colors scientific objectivity”. 2002 Annual Pew Fellows meeting, Plenary Lecture. Bonnaire, Dutch West Indies.

2002. “Complex trophic relationships in kelp forests”. 4th William R. and Lenore Mote International Symposium in Fishery Ecology, Sarasota, Florida. *Confronting tradeoffs in the ecosystem approach to fisheries management.*

2002. “Some historical dimensions to kelp forest ecosystem dynamics”. Western Society of Naturalists, Annual Meeting. Symposium on historical ecology.

2003. “Defaunated food webs: large vertebrates and nature’s balance”. 17th Annual Ricketts Memorial Lecture. Presented by the Research Community of Monterey Bay for exemplary work in the field of marine sciences.

2003. “Defaunated food webs: large vertebrates and nature’s balance”. Plenary lecture. Oregon State University, Department of Fisheries and Wildlife, Annual Graduate Student Colloquium, November 12, 2003.

2003. “Carnivory and connectivity in ‘pristine’ island food webs”. Keynote lecture, 6th California Islands Symposium, Ventura, California.

2003. “Sequential megafaunal collapse in the North Pacific Ocean: an ongoing legacy of commercial whaling?”. Plenary lecture, 15th Biennial Conference on the Biology of Marine Mammals, Greensboro, North Carolina.

2004. “Large vertebrates and nature’s balance”. 40th Annual Paul L. Errington Memorial Lecture, Iowa State University.

2004. From killer whales to kelp forests: industrial whaling and the reorganization of ocean ecosystems Capstone Lecture, Annual Meeting, American Society of Mammalogists. Arcata, California.

2004. Large predators and ecosystem resilience: examples and hypotheses from 3 case studies. Symposium on the resilience of marine ecosystems honoring the 100th

anniversary of Friday Harbor Laboratories, University of Washington.

2004. Sea otters: science, policy and the future. Keynote lecture for sea otter awareness week. Sponsored by Defenders of Wildlife, Monterey, CA

2005. From killer whales to kelp forests: connectivity in marine food webs. Spring Colloquium in Biology, University of North Carolina, Greensboro.

2005. Population status of sea otters. Keynote lecture for sea otter awareness week. Sponsored by Defenders of Wildlife, Monterey, CA

2005. From killer whales to kelp forests; chain reactions in ocean ecosystems. Distinguished Scientist Lecture, Marine Biological Laboratory, Woods Hole.

2005. The influences of large vertebrates in marine and terrestrial ecosystems. American Association for the Advancement of Science, Annual Meeting.

2006. Repatriating functionality in global ecosystems. Plenary Lecture, Annual Meeting, Society for Conservation Biology.

2006. Sea otters as predators and prey: the causes and consequences of trophic cascades. Annual Meeting, The Wildlife Society.

2009. The Aleutian archipelago: understanding carnivory from patterns of variation in space and time. Symposium on the Ecology of Place, Annual Meeting, The Ecological Society of America.

2009. Trophic downgrading of planet earth. Plenary Lecture, Annual Meeting, Western Society of Naturalists.

2010. Trophic downgrading of our planet. Plenary Lecture. Marine Biology Symposium, University of Florida, St. Augustine Marine Lab.

2011. Apex consumers and the fabric of nature. Vice President's Symposium, Society of American Naturalists/Society for the Study of Evolution, annual meeting, Norman, Oklahoma.

2012. Do trophic cascades affect the sequestration and storage of atmospheric carbon: an analysis for sea otters and kelp forests. Yale climate and energy annual conference, Yale University.

2013. Sea otters and kelp forests: an ecological history of the North Pacific Ocean. C. Hart Merriam Lecture, American Society of Mammalogists Annual Meeting, Philadelphia, PA.

2013. Trophic level complexity and its influence on population dynamics and conservation. International Mammalogical Congress, Belfast, Northern Ireland.

2014. Sea otters and kelp forests: questions, approaches, and perspectives. Hakai Institute, British Columbia

2015. The keystone species concept in ecology and management. Ecological Society of America, Annual Meeting.

2016. Adventures in nature and the pathways to ecological understanding. Western Society of Naturalists, Annual Meeting

2017. Ecology and Conservation Biology: A 50 retrospection on change. Plenary Lecture, Society for Conservation Biology, California Chapter.

2017. Serpentine food web pathways, or R.T. Paine's influence on my view of nature. Commemorative Symposium on the life and influence of Robert T. Paine, Ecological Society of America, Annual Meeting.

2018. Megafauna: the science behind big animals and why they matter. G.E. Hutchinson invited lecture. Yale University

PUBLICATIONS

Buss, I.O., and J.A. Estes. 1971. Functional significance of ear pinnae movements in the African elephant. *J. Mammal.* 52: 21-27.

Estes, J.A., and J.F. Palmisano. 1974. Sea otters: their role in structuring nearshore communities. *Science* 185: 1058-1060.

Morrison, P., M. Rosenman, and J.A. Estes. 1975. Metabolism and thermoregulation in the sea otter. *Physiol. Zool.* 47: 218-229.

Sherrod, S., J.A. Estes, and C.M. White. 1975. Depredation of sea otter pups by bald eagles at Amchitka Island, Alaska. *J. Mammal.* 56: 701-703.

Estes, J.A., and I.O. Buss. 1976. Microanatomical development and structure of the African elephant's temporal gland. *Mammalia* 40: 429-436.

Palmisano, J.F., and J.A. Estes. 1976. Sea otters: pillars of the nearshore community. *Natural History* 85: 46-53.

Estes, J.A. 1977. Population estimates and feeding behavior of sea otters, pp. 511-526 in M.L. Merritt and R.G. Fuller (eds.). The Environment of Amchitka Island. USERDA, TID-26712, Springfield, Virginia.

Palmisano, J.F., and J.A. Estes. 1977. Ecological interactions involving the sea otter. pp. 527-567 in M.L. Merritt and R.G. Fuller (eds.). The Environment of Amchitka Island. USERDA, TID-26712, Springfield, Virginia.

Simenstad, C.A., J.A. Estes, and K.W. Kenyon. 1978. Aleuts, sea otters, and alternate stable state communities. *Science* 200: 403-411.

Estes, J.A., and J.R. Gilbert. 1978. Evaluation of an aerial survey of Pacific walruses. *J. Fish Res. Board Can.* 35: 1130-1140.

Estes, J.A., N.S. Smith, and J.F. Palmisano. 1978. Sea otter predation and community organization in the western Aleutian Island, Alaska. *Ecology* 59: 822-833.

Estes, J.A. 1979. Exploitation of marine mammals: r-selection of K-strategists? *J. Fish Res. Board Can.* 36: 1209-1217.

Estes, J.A. 1980. *Enhydra lutris*. *Mammalian Species* No. 137, pp. 108, 3 Figs.

DeMaster, D.P., J.B. Faro, J.A. Estes, S.J. Taggart, and C. Zabel. 1981. Drug immobilization of walrus (*Odobenus rosmarus*). *Can. J. Fish Aq. Sci*. 38: 365-367.

Estes, J.A. 1981. Carnivorous mammals: the case of the sea otter. in P.A. Jewell and S. Holt (eds.). The Management of Locally Abundant Wild Mammals, Academic Press, New York.

Estes, J.A., R.J. Jameson, and A.M. Johnson. 1981. Food selection and some foraging tactics of sea otters. pp. 606-641 in J.A. Chapman and D. Pursley (eds.). Worldwide Furbearer Conference Proceedings, Worldwide Furbearer Conference, Inc. Frostburg, Maryland.

Estes, J.A., R.J. Jameson, and E.B. Rhode. 1982. Activity and prey selection in the sea otter: influence of population status on community structure. *Amer. Nat.* 120: 242-258.

Estes, J.A., and R.J. Jameson. 1983. Summary of available population information on California sea otters. U.S. Dept. of Interior, Minerals Management Service, POCS Technical Paper 83-11.

Estes, J.A., and V. Gol'tsev. 1984. Abundance and distribution of the Pacific walrus:

results of the first Soviet/American joint aerial survey, autumn 1975. pp. 67-76 in F.H. Fay and G.A. Fedoseev (eds.). Soviet-American cooperative research on marine mammals. Vol. 1 - Pinnipeds. NOAA Tech. Rept. NMFS 12.

Estes, J.A., and G.R. VanBlaricom. 1985. Sea otters and shellfisheries. pp. 187-235 in R.H. Beverton, D. Lavigne, and J. Beddington (eds.). Conflicts between marine mammals and fisheries. Allen and Unwin, London.

Estes, J.A. 1986. Marine otters and their environment. *Ambio* 15: 181-183.

Estes, J.A. 1986. Otters. Ecology and Conservation, by C.F. Mason and S.M. Macdonald. (Book Review) *Science* 223: 1333-1334.

Estes, J.A. 1986. The natural history of otters, by P. Chanin. (Book Review) *Am. Sci.* 74: 300-301.

Estes, J.A., K.E. Underwood, and M.J. Karmann. 1986. Activity-time budgets of sea otters in California. *J. Wildl. Mgmt.* 50: 626-636.

Irons, D.B., R.G. Anthony, and J.A. Estes. 1986. Foraging strategies of Glaucous-winged Gulls in rocky intertidal communities. *Ecology* 67: 1460-1474.

Lindberg, D.R., K.I. Warheit, and J.A. Estes. 1987. Seasonal predation and prey preference by oystercatchers on limpets at San Nicolas Island, California, USA. *Mar. Ecol. Prog. Ser.* 39:105-113.

Riedman, M., and J.A. Estes. 1988. A review of the history, distribution, and foraging ecology of sea otters. Pp. 4-21 in G.R. VanBlaricom and J.A. Estes (eds.). The community ecology of sea otters. Ecological Studies Vol. 65. Springer Verlag, New York.

Estes, J.A., and C. Harrold. 1988. Sea otters, sea urchins, and kelp beds: some questions of scale. Pp. 116-150 in G.R. VanBlaricom and J.A. Estes (eds.). The community ecology of sea otters. Ecological Studies Vol. 65. Springer Verlag, New York.

VanBlaricom, G.R., and J.A. Estes (eds.). 1988. The community ecology of sea otters. Ecological Studies Vol. 65. Springer Verlag, New York.

Estes, J.A., and P.D. Steinberg. 1988. Predation, herbivory and kelp evolution. *Paleobiology* 14: 19-36.

Estes, J.A., and G.R. VanBlaricom. 1988. Concluding Remarks. Pp. 210-218 in G.R. VanBlaricom and J.A. Estes (eds.). The community ecology of sea otters. Ecological Studies, Vol. 65. Springer Verlag, New York.

Riedman, M., and J.A. Estes. 1988. Predation on sea birds by sea otters. *Can. J. Zool.* 66: 1396-1402.

Estes, J.A., and R.J. Jameson. 1988. A double survey estimate for sighting probability of sea otters in California. *J. Wildl. Mgmt.* 52: 70-76.

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FILMS AND VIDEOS

http://www.hhmi.org/biointeractive/some-animals-are-more-equal-others-keystone-species-and-trophic-cascades. Howard Hughes Medical Institute

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The Serengeti Rules. A feature-length documentary film on keystone species and trophic cascades, scheduled for release in early 2018. Supported by HHMI and Produced by Passion Pictures, London. The film will debut at 2018 Tribeca Film Festival.

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EDUCATION:

- **University of Florida College of Veterinary Medicine,** Gainesville, FL
  - Residency in Zoological and Wildlife Medicine, 2003-2006

  Diplomate of the American College of Zoological Medicine, 2006

- **Columbia University**, New York, NY
  - **Ph.D.** in Ecology, Evolution, and Environmental Biology, 2004

  Dissertation: Disease ecology of wild and domestic carnivores in Bolivia.
  - **Advanced Certificate** in Environmental Policy, 2001

- **Angell Memorial Animal Hospital**, Boston, MA
  - **Internship** in Small Animal Medicine and Surgery, 1999

- **Tufts University School of Veterinary Medicine**, North Grafton, MA
  - **D.V.M.**, 1998

- **University of Cincinnati**, College of Arts and Sciences, Cincinnati, OH
  - **M.S.** in Biological Sciences, 1993

  Thesis: Evolutionary morphology of craniofacial growth in three breeds of rabbit.

- **Brown University**, Providence, RI
  - **A.B.** in Biology with honors, 1990

  Thesis: Reproductive success in female black-tailed prairie dogs.

AWARDS and SCHOLARSHIPS:

- Best Poster Award, American Association of Zoo Veterinarians, 2013
- American College of Zoological Medicine Manuscript Award, 2007
- American College of Zoological Medicine Manuscript Award, 2005
- Columbia University Center for Environmental Research & Conservation Fellowship, 1999-2003
- Wildlife Medicine Award, Tufts University, 1998
- National Scholar Award, Philanthropic Educational Organization Sisterhood, 1997
- New England Farm and Garden Club Scholarship, 1996, 1997
- Outstanding Master's Student of the Year Award, University of Cincinnati, 1993

GRANTS:

- Sacramento Zoo Conservation Fund, Small Grants Program, [redacted], 2014
- National Geographic, Co-PI, [redacted] 2013

- Mazuri Fund, AAZV Research Grant, [redacted] 2008
- University of Georgia competitive Faculty Research Grant, $[redacted] 2008
- University of Florida Resident Research Competition Grant, $[redacted] 2004
- National Science Foundation Doctoral Dissertation Improvement Grant, $6300, 2003
- Columbia University Graduate School Summer Merit Scholarship Grant, $[redacted] 2002
- Wildlife Conservation Society Jaguar Conservation Program Grant, [redacted], 2001-2003
- Tinker Foundation Summer Research Grant, [redacted] 2000

PROFESSIONAL EXPERIENCE:

Associate Veterinarian, Albuquerque BioPark, July 2017-present. Clinical veterinarian for Zoo and Aquarium with large, diverse collection including 3 great ape spp., an elephant breeding group, 5 big cat spp., pinnipeds, elasmobranchs, birds representing 20 orders, and both a reptile and amphibian house.

Response Veterinarian, Oiled Wildlife Care Network, School of Veterinary Medicine, University of California, Davis, May 2010-May 2017. Lead clinical veterinarian for OWCN. Director of Wildlife Health Center veterinary student externship. Responsibilities in preparedness, research, training, and response. Assisted with development of electronic medical database OWRMD for oiled wildlife response. Edited and contributed to peer-reviewed oiled wildlife care protocols for birds, sea otters, and herptiles. Scientific program chair, lecturer, and wetlab instructor for annual conference. Some teaching in DVM curriculum; mentoring of veterinary students and MPVM students. Frequent consultant to CA Fish & Wildlife Dept.

Clinical Veterinarian (part-time relief), San Francisco Zoo, CA, Aug 2011-May 2017.

Assistant Professor, University of Georgia, Oct 2007-May 2010. Tenure-track faculty member in Zoological Medicine, with responsibilities in clinical service, didactic teaching, and research. Developed new Marine Animal Medicine course. Director of native wildlife medicine program. Member of the Graduate Faculty and the interdisciplinary Faculty of Infectious Diseases.

Clinical veterinarian, Disney's Animal Kingdom, Lake Buena Vista, Florida, July 2006-July 2007. Employed through the University of Florida in one-year position as a full-time staff veterinarian for animal collections at Animal Kingdom and Epcot's Living Seas Aquarium.

Zoological Medicine Resident, University of Florida, Gainesville, 2003-2006. Clinical care of free-ranging wildlife, exotic pets, and collection animals at 4 AZA-accredited institutions: Central Florida Zoological Park, Santa Fe Teaching Zoo, St. Augustine Alligator Farm, and Lubee Bat Conservancy. Final year spent as a full-time veterinarian at White Oak Conservation Center.

Graduate Fellow, Columbia University, 1999-2003. Capture, immobilization, & sampling of free-ranging canids and felids; collaboration with local biologists and indigenous residents; analysis of domestic dog ecology; epidemiologic modeling of canine distemper virus and parvovirus transmission.

Consulting Wildlife Veterinarian

- Lambayeque, Peru, July-August 2008. Immobilization and health evaluation of captive spectacled bears; capture attempts of wild bears for satellite collaring.

- Puerto Maldonado, Peru, March 2007. Veterinary support and immobilization training for biologists on lowland tapir ecology project at Los Amigos field station in Madre de Dios.
- Barro Colorado Island, Panama, March 2002. Immobilization of ocelots for radio collar fitting. Training of field biologists in wildlife anesthetic management and animal handling.
- Monomoy National Wildlife Refuge, MA, summers 2001–2003. Veterinary support for ongoing shorebird conservation projects.

Associate Veterinarian (part-time), Riverdale Veterinary Group, NY, 2001–2003. Small and exotic animal medicine and surgery in a busy private animal hospital in New York City.

PUBLICATIONS:

Freeman, K.S., **C.V. Fiorello**, and M. Murray. 2018. Comparison of anterior segment health in wild and captive common murres. *Veterinary Ophthalmology* 21 (2): 174-181.

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Fiorello, C.V., D.J. Heard, H.B. Heller, K. Russell. 2006. Medical management of toxoplasmosis in a capuchin monkey. *JZWM* 37: 397-400.

Fiorello, C.V., S.E. Wade, R. Robbins. 2006. Parasites of free-ranging small canids and felids in the Bolivian Chaco. *JZWM* 37: 130-134.

Siegal-Willott, J., R. Isaza, **C. Fiorello**, D. Heard, M. Reinhard. 2006. *Mycobacterium asiaticum* in a red-handed tamarin (*Saguinus midas*). *JZWM* 37: 413-415.

Lafortune, M., J.F.X. Wellehan, D.J. Heard, E. Rooney-DelPino, **C.V. Fiorello**, E.R. Jacobson. 2005. Vacuum-assisted closure (Turtle VAC) in the management of traumatic shell defects in Chelonians. *Journal of Herpetological Medicine and Surgery* 15: 4-13.

Powe, J., W. Castleman, **C. Fiorello**. 2005. A thymic carcinoid in a Bengal tiger. *JZWM* 36: 531-33.

Fiorello, C.V., S.L. Deem, M.E. Gompper, E.J. Dubovi. 2004. Seroprevalence of selected pathogens in domestic carnivores on the border of Madidi National Park. *Animal Conservation* 7: 45-54.

Gompper, M.E., R. Goodman, R. Kays, J. Ray, **C.V. Fiorello**, S.E. Wade. 2003. Parasites in coyotes, *Canis latrans*, in New York. *Journal of Wildlife Diseases* 39: 712-717.

Fiorello, C.V. and R.Z. German. 1997. Heterochrony within species: Craniofacial growth in giant, standard, and dwarf rabbits. *Evolution* 51: 257-61.

BOOK CHAPTERS:

Fiorello, C.V. 2018. Seabirds and Waterfowl. In: Heatley, J.J. and K.E. Russell, eds. *Exotic Animal Laboratory Diagnosis*. Wiley-Blackwell. In press.

Fiorello, C.V. and S.J. Divers. 2012. Rabbits. In: Carpenter, J., ed. *Exotic Animal Formulary*. Elsevier.

Funk, S.M., **C.V. Fiorello**, S. Cleaveland, M.E. Gompper. 2001. The role of disease in carnivore ecology and conservation. In: *Carnivore Conservation*, J.L. Gittleman, S. Funk, B.W. Wayne, & D.W. Macdonald (eds.). Cambridge University Press.

Deem, S.L. & **C.V. Fiorello**. 2002. Capture and immobilization of free-ranging edentates. In: *Zoological Restraint & Anesthesia*, D. Heard (ed). www.ivis.org/special_books/Heard/toc.asp

ABSTRACTS AND OTHER PUBLICATIONS:

Fiorello, C., J. Lamb, Y. Satge, P. Jodice, K. Mills-Parker, M. Ziccardi. 2018. Post-release survival and movement of oiled and rehabilitated brown pelicans affected by the 2015 Refugio Oil Spill. Proceedings, Wildlife Disease Association, St. Augustine, FL.

Fiorello, C., P. Jodice, J. Lamb, Y. Satge, K. Mills-Parker, D. Jaques, L. Henkel, R. Golightly, M. Ziccardi. 2017. Post-release monitoring of oiled brown pelicans form the 2015 Refugio Oil Spill. Proceedings, International Oil Spill Conference, Long Beach, CA; Abst. #2017-119, 12 pp.

Ruvalcaba, C.A., R. Monroy, L.A. Tell, **C.V. Fiorello**, J. Last, and J-P. Delplanque. 2017. Comparison of liquid vs. dry aerosol drug delivery in a 3D printed avian trachea and mainstem bronchi model. Proceedings, Translational Science 2017, Washington, D.C.

Fiorello, C., P. Jodice, K. Mills-Parker, J. Lamb, R. Golightly, Y. Satge, D. Jaques, L. Henkel, R. McMorran, and M.H. Ziccardi. 2016. Post-release monitoring of brown pelicans (*Pelecanus occidentalis*) following oiling and rehabilitation after the Refugio oil spill. Proceedings, Pacific Seabird Group annual conference, Turtle Bay, HI.

Fiorello, C., P. Jodice, K. Mills-Parker, J. Lamb, R. Golightly, Y. Satge, D. Jaques, L. Henkel, R. McMorran, and M. Ziccardi. 2016. Post-release monitoring of oiled and rehabilitated brown pelicans (*Pelecanus occidentalis*) affected by the 2015 Refugo oil spill. Proceedings, The Wildlife Society Western Section annual conference, Pomona, CA.

Liu, J., E. McCown, **C. Fiorello,** D.G. Scorpio, M.. Filipovic, J. Saucier, B. Thatcher, and R. Chandrashekar. 2016**.** Serological survey of canine tick-borne infections using species-specific serological markers. Association of Rickettsiology conference, Big Sky, MT.

Fiorello, C.V., G. Massey, and M. Ziccardi. 2015. Use of in-house biomedical metrics to predict survival to release during rehabilitation of oiled seabirds. Proceedings, Effects of Oil on Wildlife Conference, Anchorage, AK.

Fiorello, C.V., K. Freeman, B. Elias, E. Whitmer, and M. Ziccardi. 2015. Ocular effects of dispersant exposure in common murres (*Uria aalge*): An experimental study. Proceedings, Effects of Oil on Wildlife Conference, Anchorage, AK.

Fiorello, C.V., L.M. Schwartz, J. Liu, A.K. Kownacki, and J. Foley. 2014. Multihost pathogens in, and jaguar predation on, domestic dogs in Nicaragua's Bosawás Biosphere Reserve. Proceedings, AAZV Annual Conference, Orlando, FL.

Fiorello, C.V. 2013. Schistosomiasis. In: Gamble, K.C., and M.M. Clancy (eds). Infectious Diseases of Concern to Captive and Free Ranging Animals in North America, 2nd ed. 2013. Infectious Disease Committee, American Association of Zoo Veterinarians, Yulee, Florida. 1098 pp. Website address: http://www.aazv.org/?page=IDM2013.

Fiorello, C.V., E. Bronson, J. Sohl, and M.H. Ziccardi. 2013. Exploration of methods for fibrinogen measurement in avian species. Proceedings, AAZV Annual Conf., Salt Lake City, UT.

Fiorello, C.V. 2013. Visceral Leishmaniasis. In: Gamble, K.C., and M.M. Clancy (eds). Infectious Diseases of Concern to Captive and Free Ranging Animals in North America, 2nd ed. 2013. Infectious Disease Committee, American Association of Zoo Veterinarians, Yulee, Florida. 1098 pp. Website address: http://www.aazv.org/?page=IDM2013.

Fiorello, C.V. and M.H. Ziccardi. 2012. Oiled wildlife response: bringing veterinarians into the fold. Proceedings, International Association of Aquatic Animal Medicine Annual Conf., Atlanta, GA.

Fiorello, C.V. 2012. Small Carnivore Sampling Methods Protocol. In: PREDICT One Health Consortium, USAID/PREDICT: http://www.vetmed.ucdavis.edu/ohi/predict/publications.cfm.

Fiorello, C.V. 2012. A review of fat soluble vitamin needs for piscivorous birds. Proceedings, Effects of Oil on Wildlife International Conference, New Orleans, LA.

Fiorello, C.V. 2012. Evidence-based veterinary medicine in oil spill response. Proceedings, Effects of Oil on Wildlife International Conference, New Orleans, LA.

Fiorello, C.V., S. Rivera, T. Clauss, B. Brainard, G. Rapoport, H. Murphy, and A. Berliner. 2011. Fully reversible anesthesia in Asian small-clawed otters using dexmedetomidine-butorphanol-midazolam and comparison of anesthetic and cardiac parameters with ketamine-midazolam. Proceedings, AAZV Annual Conf., Kansas City, MO.

Fiorello, C.V. and M.H. Ziccardi. 2011. Responding to oiled wildlife in the post-Deepwater Horizon World. Proceedings, AAZV Annual Conf., Kansas City, MO.

Backues, K., V. Clyde, M. Denver, **C. Fiorello**, R. Hilsenroth, N. Lamberski, S. Larsen, T. Meehan, J. Ramer, E. Ramsay, K. Suedmeyer, and D. Whiteside. 2011. Guidelines for zoo and aquarium veterinary medical programs and veterinary hospitals. JZWM 42(1): 176-192.

Deem, S.L., A.J. Noss, **C.V. Fiorello**. 2009. Biólogos y veterinarios de la conservación que trabajan en beneficio de los animales, las personas y el medio ambiente: Una asociación en el Gran Chaco, Bolivia. Fauna Vet Peru: Revista Virtual 2 (4): pp. 4-9.

Deem, S.L., **C.V. Fiorello**, M. Cunningham, et al. 2009, 2013. Guidelines for veterinarians interested in *in situ* conservation and free-ranging wildlife health projects. American Association of Zoo Veterinarians, http://www.aazv.org/displaycommon.cfm?an=1&subarticlenbr=20

Fiorello, C.V. 2007. Review of *Bears: Health and Management*, by D.C. Bourne and G. Vila-Garcia. JAVMA 232: 1813.

INVITED TALKS:

Fiorello, C.V. 2012. *Latin American Conservation*. UC Davis School of Veterinary Medicine Hot Topics Lecture Series, Davis, CA.

Fiorello, C.V. 2008. *Disease transmission between wildlife and domestic animals*. Eighth International Congress on Management of Wildlife of Amazonia and Latin America, Rio Branco, Brazil.

Fiorello, C.V. 2003. *Disease ecology of wild and domestic carnivores in Bolivia*. ProCarnivoros First Workshop on Neotropical Carnivore Conservation, Atibaia, Brazil.

PROFESSIONAL AFFILIATIONS & SERVICE:

- American Association of Zoo Veterinarians, member 1996-present
  - Co-chair, Research Committee, 2015-2016
  - Chair, Research Committee, 2016-2017
  - Executive Committee member, 2009-2011
  - Co-Chair, Committee on Wildlife Health and Conservation, 2008-2013
  - Infectious Disease Committee, member 2008-present
  - Session Chair, Greening of Veterinary Medicine, 2009 annual conference
  - Session Chair, Notes from the Field, 2010 annual conference
  - Session Chair, Disaster Management, 2013 annual conference
  - Strategic Planning meeting, 2015

- American College of Zoological Medicine
  - Chair, Wildlife Section of Exam Committee, 2012-present
  - Ad-hoc Committee on Training Program Standards, Structure, and Evaluation, member 2011-present

- American Association of Wildlife Veterinarians, member 2000-2016
  - Instructor, Wildlife Capture workshop, 2013
  - Annual auction coordinator, 2007, 2009
  - Co-coordinator, Tools for Veterinarians in Wildlife Field Research workshop, 2009

- Wildlife Disease Association, member 1999-present

- American Veterinary Medical Association, member 1994-present
- Reviewer for:
  - Journal of Wildlife Diseases
  - Journal of Zoo & Wildlife Medicine
  - Ecohealth
  - PLoS One
  - Journal of the American Veterinary Medical Association
  - Avian Diseases
  - Journal of Parasitology
  - Epidemiology & Infection
  - Environmental Monitoring & Assessment
  - Integrative Zoology
  - IUCN Cat News
  - Zoo Biology
  - European Journal of Wildlife Research
  - New Zealand Journal of Marine and Freshwater Research
  - Ecological Applications

GOVERNMENTAL SERVICE

- US Fish & Wildlife Service Marbled Murrelet Expert Panel and Recovery Implementation Team, member 2011-present

VETERINARY LICENSES:

- New Mexico
- California
- Massachusetts
- New York (inactive)
- USDA federally accredited

HEATHER S. HARRIS, DVM, MPVM, DACVPM
[redacted]
Cell [redacted]

EDUCATION

2017 **Diplomate, American College of Veterinary Preventive Medicine**
Specialty board certification

2008 **Master of Preventive Veterinary Medicine: Wildlife Disease Ecology**
University of California, Davis, School of Veterinary Medicine

2006 **Doctor of Veterinary Medicine: Wildlife Medicine Track**
University of California, Davis, School of Veterinary Medicine

1996 **Bachelor of Arts: Environmental Studies**
University of California, Santa Barbara

CURRENT PROFESSIONAL LICENSES AND CERTIFICATIONS

2010-Present DEA License for Controlled Substances, Type A Practitioner

2006-Present California State Veterinary License (#16410)

2006-Present 24-HOUR HAZWOPER Certification, Oiled Wildlife Care Network

POST-DOCTORAL TRAINING

2007-2008 **Internship: Marine Mammal Medicine and Pathology, The Marine Mammal Center / UC Davis**
Provided advanced medical care to free-ranging marine mammals in a high-volume rehabilitation hospital (critical care, anesthesia, surgery, radiology, clinical care, and necropsy). Performed field anesthesia and biological sampling for collaborative research projects on remote pinniped rookeries. Conducted research studies on infectious disease surveillance and pathology. Trained and supervised veterinary students and interfaced with the media.

CURRENT POSITIONS

2015-Present **Veterinarian/Lecturer, California Polytechnic State University, San Luis Obispo, CA**
Develop and teach new hands-on courses with One Health focus for upper division undergraduate students in the Animal Science Department. Affiliated faculty with the Center for Coastal Marine Sciences. Provide veterinary support for field research on elephant seals at Piedras Blancas rookery and Weddell seals in Antarctica.

- ASCI 270: Global One Health Topics
- ASCI 290: Marine Mammal Health Enterprise (in partnership with The Marine Mammal Center)
- Guest lectures: BIO 227 (Wildlife Conservation Biology), MSCI 100 (Intro to Marine Science), MSCI 324 (Marine Mammals, Birds, and Reptiles), ASCI 312 (Production Medicine).

2008-Present **Wildlife Veterinarian, The Marine Mammal Center, San Luis Obispo Field Office, CA (contract)**
Provide emergency medical care to sick and injured stranded pinnipeds, sea otters, and cetaceans. Participate in field capture operations of sea otters, perform surgical implantation of intraperitoneal telemetry devices from mobile veterinary labs, and conduct biological sampling for disease surveillance. Perform postmortem exams and collect samples for population health investigations. Teach training classes for interns, veterinary students, and volunteers.

2006-Present **Wildlife Veterinarian, NOAA Protected Resources Division, West Coast Region (contract)**
Lead population level health investigations of endangered sea turtles and their prey on foraging grounds and nesting beaches in the Pacific/Atlantic/Caribbean. Provide field veterinary support for boat-based captures, nesting beach monitoring, and mass stranding events. Develop field methods for biological sampling of leatherback turtles (fat biopsies, ultrasonography, blood collection, skin samples). Teach multi-agency workshops on sea turtle stranding response and participate in scientific working groups addressing threats to survival. Provide veterinary expertise for permits, IACUC protocols, emergency response protocols for field captures, and best practices for safety in research.

PROFESSIONAL EXPERIENCE

2010-2018 **Shelter Veterinarian (part-time), Woods Humane Society, San Luis Obispo, CA (contract)**
Perform high-volume surgical procedures (spay/neuter, biopsy, mass removal, trauma repair, enucleation, etc.). Provide medical care, emergency response, and infectious disease management for small animals in a shelter setting.

2015 **Supervisor: Marine Mammal Field Stabilization, Oiled Wildlife Care Network, Davis, CA (contract)**
Staff position in group supervisory role during Refugio Incident. Led field stabilization efforts for live oiled marine mammals recovered from the spill zone including medical evaluation, clinical care, and evidence sampling. Trained staff and volunteers to assist with stabilization procedures following chain of custody protocols.

2007-2011 **Wildlife Veterinarian, NOAA National Marine Mammal Lab, Seattle, WA (contract)**
Field veterinarian for annual capture operations of Steller sea lions and northern fur seals on remote Alaskan island rookeries at Kodiak, Pribilof, and Aleutian Islands. Performed field anesthesia on hundreds of juvenile and adult pinnipeds, collected biological samples, and conducted postmortem exams on dead animals in the rookeries.

2009-2010 **Wildlife Veterinarian, NOAA Hawaiian Monk Seal Research Program, Honolulu, HI (contract)**
Conducted two field seasons of deworming trials on Hawaiian monk seals at a remote island rookery on Laysan Island, NW Hawaiian Islands. Trained field staff to safely capture and restrain seals, administer oral and injectable medications, collect biological samples, and perform necropsies.

2006-2008 **Wildlife Veterinarian, Moss Landing Marine Laboratories, CA (contract)**
Provided veterinary support for captures of wild harbor seals on remote island rookeries at the California Channel Islands and along California mainland coast. Performed sedation, collected blood and fat biopsies, monitored animals, and provided emergency response.

2007-2008 **Emergency Veterinarian, Sacramento Emergency Vet Clinic, Sacramento, CA**
Provided emergency and critical care to sick and injured small animals including stabilization, diagnostic imaging, anesthesia, surgical procedures, and euthanasia.

1999-2002 **Scientific Aid, California Department of Fish and Game, Office of Spill Prevention and Response, Marine Wildlife Veterinary Care and Research Center, Santa Cruz, CA**
Assisted with population health research on southern sea otters though live field captures and necropsies of dead stranded animals. Participated in oil spill response of seabirds including field search and collection, intake, stabilization, washing, and necropsy following chain-of-custody protocols.

TEACHING EXPERIENCE

2018 **Live Sea Turtle Response Lab, West Coast Regional Stranding Conference, Seattle, WA**
Led hands-on interactive lab for on live sea turtle response and stabilization for marine mammal responders.

2017 **Sea Turtle 101 Lab, Oilapalooza Conference, Oiled Wildlife Care Network, Monterey, CA**
Led hands-on interactive lab with live sea turtles for oiled wildlife responders at the Monterey Bay Aquarium.

2016 **Pacific Northwest sea turtle stranding workshop, USFWS/NOAA, Portland, OR**
Led 2-day training workshop to build capacity for sea turtle response along the west coast of US and Canada.

2016 **Basic and advanced necropsy labs, National Marine Animal Health and Stranding Meeting, Shepherdstown, WV**
Led multiple trainings on anatomy and necropsy techniques of marine turtles for stranding network.

2014 **Sea turtle necropsy workshop, NOAA, Southwest Fisheries Science Center, La Jolla, CA**
Led 3-day training workshop on sea turtle necropsy techniques for NOAA scientists and stranding network.

2014 **Sea turtle webinar, Oiled Wildlife Care Network, Davis, CA**
Developed online webinar on oiled sea turtle response in California for staff and volunteer training.

2013 **Marine wildlife anatomy lab, Moss Landing Marine Laboratories, Moss Landing, CA**
Taught comparative necropsy lab for graduate students in marine science.

2012 **Sea turtle necropsy course, Oiled Wildlife Care Network, Santa Cruz, CA**
Led sea turtle necropsy class focusing on normal anatomy and basic data collection.

2011-2016 **Comparative anatomy labs, The Marine Mammal Center, San Luis Obispo Field Office, CA**
Teach annual necropsy classes on comparative anatomy of pinnipeds and sea otters for volunteers.

2011-2015 **Sea turtle anatomy labs, West Coast Regional Stranding Network, San Pedro, CA**
Teach annual labs for sea turtle stranding response protocols and basic data collection.

2009 **Seabird lab, California Council of Wildlife Rehabilitators, Shell Beach, CA**
Taught clinical anatomy for seabird oral feeding and injections to wildlife rehabilitators.

2008 **Pinniped necropsy lab, Michigan State University, East Lansing, MI**
Led comparative necropsy lab focusing on pinniped anatomy and disease for veterinary students.

2008 **MARVET Program, Sausalito, CA**
Taught medical procedures for rehabilitated pinnipeds to international veterinarians.

2007-2008 **Marine mammal medicine, The Marine Mammal Center, Sausalito, CA**
Trained senior veterinary students during clinical rotations in marine mammal medicine and pathology.

2003-2005 **Wildlife necropsy labs, Wildlife Medicine Club, University of California, Davis, CA**
Organized and assisted with teaching wildlife necropsies for veterinary students and residents.

OIL SPILL EXPERIENCE

2015 **Refugio Incident, Oiled Wildlife Care Network, Santa Barbara/Ventura counties, CA**
OWCN staff position: Group Supervisor, Marine Mammal Field Stabilization

2012 **Platform Houchin Spill, Oiled Wildlife Care Network, Ventura, CA**
Wildlife reconnaissance of marine birds and mammals.

2007 **Cosco Busan Oil Spill, Oiled Wildlife Care Network, San Francisco Bay/Cordelia, CA**
Field search and collection, intake, stabilization, and washing of oiled seabirds.

2002 **S.S. Jacob Luckebach Oil Spill, California Department of Fish and Game, Santa Cruz, CA**
Field search and collection and stabilization of oiled seabirds.

2001 **San Mateo Mystery Spill, California Department of Fish and Game, Santa Cruz, CA**
Necropsies of dead oiled seabirds held as evidence.

1999 **Point Reyes Tarball Incident, California Department of Fish and Game, Santa Cruz, CA**
Necropsies of dead oiled seabirds held as evidence.

RESEARCH GRANTS

2018 U.S. Fish and Wildlife Service, Recovery Project Cooperative Agreement (PI), [redacted]

2018 National Fish and Wildlife Foundation, Ocean Health Initiative (PI), $[redacted]

2010-2012 NOAA Oceans and Human Health Initiative Research Grant (co-PI), [redacted]

2008-2011 Oiled Wildlife Care Network Research Grant (co-PI), [redacted]

2005-2007 Oiled Wildlife Care Network Research Grant (co-PI), $[redacted]

2004 STAR Research Fellowship, University of California, Davis (co-PI), [redacted]

2003 Geraldine R. Dodge Foundation, Frontiers for Veterinary Medicine Research Grant (co-PI), [redacted]

SCHOLARSHIPS

2015 Humane Alliance Scholarship, Advanced surgical training, Asheville, NC

2006-2007 Theodora Peigh Dual Degree DVM/MPVM Scholarship, University of California, Davis

2005-2006 Peigh Memorial Scholarship, University of California, Davis

SELECTED PUBLICATIONS

Harris, H., M. Flint, K. Stewart, and C. Harms. 2017. Chapter 34: Field Techniques. *In* Sea Turtle Health and Rehabilitation, 1st edition (eds. Manire, Norton, Stacy, Innis, and Harms). J Ross Publishing Inc., Plantation, FL, pp. 819-852.

Deem, S. and **H. Harris**. 2017. Chapter 39: Health assessments. *In* Sea Turtle Health and Rehabilitation, 1st edition (eds. Manire, Norton, Stacy, Innis, and Harms). J. Ross Publishing Inc., Plantation, FL, pp. 945-953.

Ferguson, S., J. Wellehan, S. Frasca, C. Innis, **H. Harris,** M. Miller, E. Weber, H. Walden, E. Greiner, C. Merigo, and B. Stacy. 2016. Coccidial infection of the adrenal glands of leatherback sea turtles (*Dermochelys coriacea*). Journal of Wildlife Diseases 52(4): 874-882.

Harris, H., S. Benson, M. James, K. Martin, B. Stacy, P. Daoust, P. Rist, T. Work, G. Balazs, and J. Seminoff. 2016. Validation of ultrasound as a noninvasive tool to measure subcutaneous fat depth in leatherback sea turtles (*Dermochelys coriacea*). Journal of Zoo and Wildlife Medicine 47(1): 275-279.

Stacy, B., C. Innis, P. Daoust, J. Wyneken, M. Miller, **H. Harris**, M. James, E. Christiansen, and A. Foley. 2014. Solitary large intestinal diverticulitis in leatherback turtles (Dermochelys coriacea). Veterinary Pathology Online DOI: 10.1177/0300985814549211.

Harris, H., S. Benson, K. Gilardi, R. Poppenga, P. Dutton, T. Work, and J. Mazet. 2011. Comparative health assessment of Western Pacific leatherback turtles (*Dermochelys coriacea*) foraging off the coast of California. Journal of Wildlife Diseases 47(2):321-337.

Harris, H., P. Facemire, D. Greig, K. Colegrove, G. Ylitalo, G. Yanagida, M. Fleetwood, F. Nutter, and F. Gulland. 2011. Congenital neuroglial heterotopia in a neonatal harbor seal (*Phoca vitulina richardsi*) with evidence of recent petroleum exposure. Journal of Wildlife Diseases 47(1):246-254.

Harris, H., S. Oates, M. Staedler, M. Tinker, D. Jessup, J. Harvey, and M. Miller. 2010. Lesions associated with forced copulation of juvenile harbor seals by southern sea otters. Aquatic Mammals 36(4):331-341. DOI 10.1578/AM.36.4.2010.219

SCIENTIFIC CONFERENCE ABSTRACTS

Harris, H. 2018. Cold-stunned sea turtle response along the U.S. west coast. Sea Turtle Medicine Workshop, International Sea Turtle Symposium, Kobe, Japan, February 19-23.

Harris, H. and J. Greenman. 2016. Wildlife response and field stabilization: Refugio case study. National Marine Animal Health and Stranding Network Conference, Shepherdstown, West Virginia, Sept 6-9.

Harris, H., S. Benson, M. James, K. Martin, B. Stacy, P. Daoust, P. Rist, T. Work, G. Balazs, and J. Seminoff. 2015. Validation of ultrasound as a noninvasive tool to measure subcutaneous fat in leatherback sea turtles. Proceedings of the 46th Annual Conference of the International Association of Aquatic Animal Medicine, Chicago, Illinois, April 6-10.

Harris, H., R. LeRoux, C. Fahy, and J. Seminoff. 2015. Sea turtle necropsy workshop: Case highlights. West Coast Marine Mammal Stranding Regional Meeting, Long Beach, California, March 23-25.

Harris, H., S. Benson, S. Fire, M. Miller, B. Stacy, R. Kudela, C. Fahy, and J. Seminoff. 2014. Domoic acid in the leatherback turtle food web on critical foraging grounds in central California. California Marine Mammal Stranding Network Meeting, La Jolla, California, February 6-8.

Harris, H., S. Benson, M. Miller, S. Fire, B. Stacy, R. Kudela, C. Fahy, and J. Seminoff. 2013. Domoic acid in the leatherback turtle food web on critical foraging grounds in central California. Proceedings of the 44th Annual Conference of the International Association of Aquatic Animal Medicine, Sausalito, California, April 21-25.

Harris, H., S. Benson, M. James, K. Martin, B. Stacy, C. Innis, J. Cavin, P. Daoust, P. Rist, T. Work, G. Balazs, and J. Seminoff. 2013. Validation of ultrasonography as a noninvasive diagnostic tool to measure subcutaneous fat depth in leatherback turtles. Proceedings of the 33rd Annual Symposium on Sea Turtle Biology and Conservation. International Sea Turtle Society, Baltimore, Maryland, February 4-8.

Harris, H., S. Fire, S. Benson, C. Fahy, and J. Seminoff. 2012. Scyphozoan jellies as biological sensors for domoic acid on critical foraging grounds for the leatherback turtle. CalCOFI conference, Monterey, California, Dec 4.

Harris, H., S. Fire, S. Benson, C. Fahy, and J. Seminoff. 2012. Scyphozoan jellies as biological sensors for domoic acid on critical foraging grounds for the leatherback turtle. Gordon Research Conference on Oceans and Human Health, Biddeford, Maine, June 2-8.

Harris, H., S. Benson, G. Ylitalo, S. Fire, R. Poppenga, C. Fahy, and J. Seminoff. 2011. Evaluation of scyphozoan jellyfish as biological indicators for coastal marine pollution and leatherback turtle health. Proceedings of the 31st Annual Symposium on Sea Turtle Biology and Conservation. International Sea Turtle Society, San Diego, California, April 10-16.

Harris, H., C. Fahy, R. LeRoux, S. Benson, E. LaCasella, S. Wilkin, P. Dutton, and J. Seminoff. 2010. Integrating health research into leatherback turtle stranding response in California. National Marine Animal Health and Stranding Network Conference, Shepherdstown, West Virginia, April 6-9.

Harris, H., S. Benson, P. Dutton, K. Gilardi, R. Poppenga, T. Work, and J. Mazet. 2009. Incorporating health studies in the conservation of western Pacific leatherback turtles. The Wildlife Society, Monterey, California, September 20-24.

Harris, H. Leatherback turtle strandings in California: What can we learn? 2009. California Regional Stranding Network Meeting. Santa Barbara Museum of Natural History, Santa Barbara, CA, March 16-18.

Harris, H., S. Benson, P. Dutton, K. Gilardi, R. Poppenga, T. Work, and J. Mazet. 2009. Comparative health assessment of Western Pacific leatherback turtles (*Dermochelys coriacea*) foraging off the coast of California, 2005-2007. Proceedings of the 29th Annual Symposium on Sea Turtle Biology and Conservation. International Sea Turtle Society, Brisbane, Australia, February 17-19.

Harris, H., S. Benson, K. Gilardi, R. Poppenga, P. Dutton, T. Work, and J. Mazet. 2008. Health assessment of foraging Pacific leatherback turtles off the coast of California. Proceedings of the 39th Annual Conference of the International Association for Aquatic Animal Medicine, Rome, Italy, May 10-14.

Harris, H., M. Miller, and P. Conrad. 2004. Aggressive interspecific sexual behavior in the southern sea otter. Student Training in Advanced Research Fellowship Seminar, University of California, Davis, CA.

Harris, H., D. Jessup, and J. Mazet. 2004. Development of a comprehensive database for health monitoring of the southern sea otter as an indicator of marine ecosystem health. Geraldine R. Dodge Foundation, Frontiers for Veterinary Medicine Conference, White Oak Conservation Center, Yulee, FL.

INVITED TALKS

Harris, H. 2017. Living dinosaurs: leatherback sea turtles along the central coast. Sharks-After-Dark lecture series, Central Coast Aquarium, Avila Beach, CA, Nov 16.

Harris, H. 2017. Marine wildlife veterinary medicine. Cal Poly Wildlife Club, San Luis Obispo, CA, Oct 12.

Harris, H. 2017. Leatherback health: a one health perspective. Moss Landing Marine Laboratories: Leatherback Conservation Day, Moss Landing, CA, Oct 13.

Harris, H. 2017. West coast sea turtle health: A conservation medicine perspective. Cal Poly Biological Sciences Seminar Series, Feb 17.

Harris, H. 2016. Integrating marine mammals at Cal Poly. Friends of the Elephant Seal, Cambria, CA, Nov 16.

Harris, H. 2016. Careers in marine wildlife health. Cal Poly Zoo and Exotics Club, San Luis Obispo, CA, Mar 3.

Harris, H. 2014. A big picture look at the biotoxin domoic acid in diverse marine food webs. Monterey Bay National Marine Sanctuary Seminar Series, Cambria, CA, May 9.

Harris, H. 2013. Leatherback health connections. The Leatherback Summit, Monterey, CA, Oct 14.

Harris, H. 2013. Dinosaurs of the ocean. Central Coast Aquarium, Avila Beach, CA, Aug 16.

Harris, H. 2013. Sea turtle population health. Moss Landing Marine Labs, Moss Landing, CA, Apr 17.

Harris, H. 2012. The health of sea turtles in California. The Marine Mammal Center, Morro Bay, CA, Dec 12.

Harris, H. 2012. California live sea turtle stranding protocol. California Marine Mammal Stranding Network Meeting, San Pedro, CA, Nov 15.

Harris, H. 2012. Sea turtle populations in California: Implications for oil spill response. Oiled Wildlife Care Network, Oilapalooza Conference, Santa Cruz, CA, Oct 27.

Harris, H. 2012. Careers in marine wildlife health. Stanford University, Department of Comparative Medicine, Pre-Vet Expo III, Palo Alto, CA, May 19.

Harris, H. 2012. Endangered western Pacific leatherback turtles: Health assessment of turtles and their prey on critical foraging grounds in central California. Morro Coast Audubon Society, Community Program. San Luis Obispo, CA, March 19.

Harris, H. 2012. Health investigations of endangered Pacific leatherback turtles and their prey on critical foraging grounds in central California. California Polytechnic State University, Biological Sciences Seminar Series, San Luis Obispo, CA, March 9.

Harris, H. 2009. Pinniped health studies: from monk seals in the tropics to fur seals in the arctic. Educational Research Update. The Marine Mammal Center, Morro Bay, CA, November 11.

Harris, H. 2009. Comparative health assessment of Western Pacific leatherback turtles foraging off the coast of California. NOAA Southwest Fisheries Science Center, Seminar Series. La Jolla, CA, April 14.

Harris, H. 2008. The role of vets in wildlife health. Marine Wildlife Lecture Series. Michigan State University, School of Veterinary Medicine, Lansing, MI, November 14.

Harris, H. 2008. California sea lions: Common clinical diseases in rehabilitation. Marine Wildlife Lecture Series, Michigan State University, School of Veterinary Medicine, East Lansing, MI, November 13.

Harris, H. 2008. Leatherback sea turtle health monitoring. Educational Research Update. The Marine Mammal Center, Sausalito, CA, May 29.

SPECIALTY TRAININGS

2016	ICS 100, 200, 700, Federal Emergency Management Agency
2014	Field Stabilization, Levels 1 and 2, Oiled Wildlife Care Network
2012	Veterinary Care of Oiled Sea Otters, Oiled Wildlife Care Network
2005	Oiled Wildlife Care, UC Davis Wildlife Health Center
2004	Dart-gun Handling, UC Davis Wildlife Health Center
2003	Wildlife Capture and Restraint, California Department of Fish and Game
2001	Advanced Supervisor for Oil Spill Response, Oiled Wildlife Care Network
2001	Wildlife Necropsy Techniques, California Department of Fish and Game
2000	Basic Supervisor for Oil Spill Response, Oiled Wildlife Care Network
1999	Small Boat Operation, California Department of Boating and Waterways
1996	Open Water SCUBA, NAUI

PROFESSIONAL SERVICE

2018	38th International Sea Turtle Symposium: Session Chair, Anatomy/Physiology/Health Session, Kobe, Japan, Feb 19-23.
2016	National Marine Animal Health and Stranding Network Conference: Steering Committee, Necropsy and Population Health subcommittees, Shepherdstown, WV, Sep 6-9.
2013	44th International Association of Aquatic Animal Medicine: Session Chair, Turtle Health and Medicine Session, Sausalito, CA, Apr 21-25.
2013	33nd International Sea Turtle Symposium: Session Chair, Anatomy/Physiology/Health Session, Baltimore, MD, Feb 3-8.
2011	31st International Sea Turtle Symposium: Sea Turtle Medicine Workshop, San Diego, CA, Apr 11.
2010-Present	Journal reviewer: Wildlife Disease Association, Endangered Species Research, Chelonian Conservation and Biology.
2005	11th Annual Wildlife Medicine Symposium, Organizer/Moderator, UC Davis, Jan 29.
2004-05	American Association of Wildlife Veterinarians: President, UC Davis Student Chapter.

PROFESSIONAL AFFILIATIONS

2017-Present	American College of Preventive Veterinary Medicine
2008-Present	International Association for Aquatic Animal Medicine
2006-Present	International Sea Turtle Society
2006-Present	American Veterinary Medical Association
2002-Present	Wildlife Disease Association

Curriculum Vitae

Michael C. Kenner

PRESENT ADDRESS: USGS Pacific Coastal and Marine Science Center
WERC Santa Cruz Field Station
2885 mission St, Santa Cruz CA 95060

EDUCATION: BS University of California, Irvine 1980 Biological Sciences

MS California State University, Hayward and Moss Landing Marine Laboratories 1988 Marine Sciences

WORK EXPERIENCE:

Current — Wildlife Biologist at USGS Santa Cruz Field Station
Duties as below

1985 to 2019 — Marine Technician, University of California Santa Cruz
Manage semi–annual long-term baseline surveys of intertidal and subtidal sites at San Nicolas Island, CA. Collect data on densities, size distributions, growth, and food habits of intertidal and kelp forest organisms. Lead or assist with field studies on kelp forest and intertidal communities. Manage annual black abalone surveys at SNI. Enter and manage data for long term projects. Write annual reports for SNI subtidal and abalone monitoring for US. Navy. Assist with capture, handling, and transport of sea otters; assist with semiannual census of California sea otters. Assist with analysis of sea otter population and habitat data. Assist with sea otter telemetry projects. Participate in sea otter carcass recovery program.

1984 – 1985 — Biological Technician, US Fish and Wildlife Service
Assist with field work on kelp forest and intertidal communities. Enter data and assist with data management. Purchase and maintain equipment for USFWS Santa Cruz field station.

1983 – 1984 — Biological Technician, California Department of Fish and Game
Assist with field collections, data entry/management, and laboratory preparation of samples for trace metal contaminants analysis for the State Mussel Watch program.

1983 — Teaching Assistant, Moss Landing Marine Lab
Marine Phycology

PUBLICATIONS AND PAPERS:

Kenner, M.C. 1987. Population ecology of Strongylocentrotus purpuratus inhabiting sublittoral coralline mats within the range of the sea otter in California. M.S. Thesis, California State University, Hayward and Moss Landing Marine Laboratories, CA, 64pp.

Bodkin, J.L. and M.C. Kenner. 1988. A preliminary report on the demography of the spiny lobster, Panulirus interruptus, at San Nicolas Island, CA Fifth Biennial Mugu Lagoon / San Nicolas Island Symposium Proceedings, Pt. Mugu, CA 1988, pp. 75-82.

Kenner, M.C. and M.T. Lares 1991. Size at first reproduction of the sea urchin Strongylocentrotus purpuratus in a central California kelp forest. Mar. Ecol. Prog. Ser. 76: 303-306.

Kenner, M.C. 1992. Population dynamics of the sea urchin Strongylocentrotus purpuratus in a central California kelp forest: recruitment, mortality, growth, and diet. Mar. Biol. 112: 107-118.

T. A. Ebert, J. C. Hernández, S. Clemente, M. P. Russell, L. V. Basch, R. A. Boolootian, P. M. Detwiler, M. C. Kenner, A. L. Lawrence, J. M. Lawrence, D. L. Leighton, J. S. Palleiro, and J. S. Pearse 2013. Half a century (1954-2009) of dissection data of sea urchins from the North American pacific coast (Mexico to Canada). Ecology 94:2109–2110.

Kenner, Michael C., James A. Estes, M. Tim Tinker, James L. Bodkin, Robert K. Cowen, Christopher Harrold, Brian B. Hatfield, Mark Novak, Andrew Rassweiler, and Daniel C. Reed 2013. A multi-decade time series of kelp forest community structure at San Nicolas Island, California (USA). Ecology 94:2654–2654

Kira A. Krumhansl, Daniel K. Okamoto, Andrew Rassweiler, Mark Novak, John J. Bolton, Kyle C. Cavanaugh, Sean D. Connell, Craig R. Johnson, Brenda Konar, Scott D. Ling, Fiorenza Micheli, Kjell M. Norderhaug, Alejandro Pérez-Matus, Isabel Sousa-Pinto, Daniel C. Reed, Anne K. Salomon, Nick T. Shears, Thomas Wernberg, Robert J. Anderson, Nevell S. Barrett, Alejandro H. Buschmann, Mark H. Carr, Jennifer E. Caselle, Sandrine Derrien-Courtel, Graham J. Edgar, Matt Edwards, James A. Estes, Claire Goodwin, Michael C. Kenner, David J. Kushner, Frithjof E. Moy, Julia Nunn, Robert S. Steneck, Julio Vásquez, Jane Watson, Jon D. Witman, and Jarrett E. K. Byrnes 2016. Global patterns of kelp forest change over the past half-century. PNAS 113: 13785-13790.

Kenner, M.C., 2016. "San Nicolas Island Kelp Forest Monitoring - First Annual Report - Fiscal Year 2015". A report to the US Navy. University of California, Santa Cruz, CA. 61 pages

Kenner,M.C., 2016. "Kelp Forest Monitoring at Naval Base Ventura County, San Nicolas Island, CA Fall 2015 and Spring 2016 - Second Annual Report". A report to the US Navy. University of California, Santa Cruz, CA. 68 pages.

Ebert, Thomas; Barr, Louis; Bodkin, James; Burcham, Dirk; Bureau, Dominique; Carson, Henry; Caruso, Nancy; Caselle, Jennifer; Claisse, Jeremy; Clemente, Sabrina; Davis, Katie; Detwiler, Paul; Dixon, John; Duggins, David; Engle, John; Estes, James; Groth, Scott; Grupe, Benjamin; Halmay, Peter; Hebert, Kyle; Hernández, José Carlos; Jurgens, Laura; Kalvass, Peter; Kenner, Michael; Konar, Brenda; Kushner, David; Lee, Lynn; Leighton, David; Montaño-Moctezuma, Gabriela; Munk, Eric; Olguin Espinoza, Irma; Palleiro, Julio; Parker, David; Pearse, John; Pondella, II, Daniel; Rogers-Bennett, Laura; Schroeter, Stephen; Shelton, Andrew; Sonnenholzner, Jorge; Taniguchi, Ian; VanBlaricom, Glenn; Watson, Jane; Weitzman, Benjamin; Williams, Jonathan; Yakimishyn, Jennifer; Zhang, Zane, 2018. Size, growth, and density data for shallow-water sea urchins from Mexico to the Aleutian Islands, Alaska, 1956–2016. Ecology 99(3): 761-761.

M.C. Kenner, 2018. "Kelp Forest Monitoring at Naval Base Ventura County, San Nicolas Island, CA Fall 2016 and Spring 2017 - Third Annual Report". A report to the US Navy. University of California, Santa Cruz, CA. 81 pages.

Kenner, Michael C., and M. Tim Tinker, 2018. Stability and Change in Kelp Forest Habitats at San Nicolas Island. Western North American Naturalist 78(4).

PAPERS GIVEN:

Ecology of a cryptic population of Strongylocentrotus purpuratus inhabiting sublittoral coralline mats. 66th Annual Meeting of the Western Society of Naturalists, December 1985

Macrocystis canopy and kelp recruitment cycling at San Nicolas Island, California. 71st Annual Meeting of the Western Society of Naturalists, December 1990.

Subtidal ecosystem changes at San Nicolas Island. Michael C. Kenner and James A. Estes, California. Sixth California Islands Symposium, December 2003

San Nicolas Island Subtidal baseline Project: Over 30 years and still counting, Eighth California Islands Symposium, October 2012

Stability and change in kelp forest habitats at San Nicolas Island, Michael C. Kenner and Martin T. Tinker. Ninth California Islands Symposium, October 2016

Lesanna L Lahner DVM, MPH

PROFESSIONAL OBJECTIVE

To promote conservation and improve ecosystem and community health through exceptional veterinary medical care, research, and translational science.

EDUCATION

Doctor of Veterinary Medicine (DVM)
University of Wisconsin – Madison, WI. GPA 3.8, 2006-2011

Master of Public Health (MPH)
University of Wisconsin – Madison, WI. GPA 3.9, 2008-2010

Bachelor of the Arts (BA)
Carleton College, Northfield, MN. Biology, 2000-2004

WILDLIFE VETERINARY MEDICINE and RESEARCH EXPERIENCE

Lead Veterinarian, Interim, Minnesota Zoological Gardens, Apple Valley, MN
2017- current, full-time

- Develop, implement, and maintain cutting edge preventive medicine program for a large (5,000 + animals) and diverse collection of wildlife.
- Provide timely and appropriate veterinary medical care for sick and injured animals.
- Manage a team of veterinarians and veterinary technicians to ensure clear communication regarding animal health care to promote excellent welfare.

Execute Director and Veterinarian, SR^3 Sealife Response, Rehab, and Research Seattle, WA
2016- 2018, full-time

- Overall strategic and operational responsibility for staff, programs, construction of a new facility, and execution of the mission.
- Develop core scientific and medical programs, operations, and a sustainable business plan.
- Manage field and onsite veterinary care including stranded/injured wildlife response as well as medical aspects of research programs.
- Provide emergency veterinary medical care for marine mammals and birds.
- Develop, maintain, and support a strong Board of Directors and build board involvement with strategic direction.

AWARDS & HONORS

[redacted]

Vilas Zoological Scholarship,
Connor DVM/MPH
Scholarship

[redacted] [redacted] lesanna.lahner@state.mn.us

Veterinarian, Sarvey Wildlife Rehabilitation Center, Arlington, WA

2012-present, part-time

- Provide veterinary medical care, including surgery and intensive care, for a variety of native wildlife species with an emphasis on birds of prey such as bald eagles, hawks, and owls.
- Work with state and federal agencies to ensure priorities are met for wildlife recovery and rehabilitation.
- Perform necropsies and obtain information on local wildlife disease issues for surveillance of important emerging diseases such as highly pathogenic avian influenza, White Nose Syndrome, and more.

Affiliate Professor, University of Washington, Seattle WA

2015-present, part-time

- Lecture for and mentor students from a variety of programs including the MPH, MD, and PhD students associated with the Center for One Health Research and Environmental Health.

Relief Veterinarian, PAWS Wildlife Center, Seattle WA

2012-present, part-time

- Provide veterinary care, including surgery and intensive care, for a variety of native wildlife species.

Staff Veterinarian, Seattle Aquarium, Seattle, WA

2011-2016, full-time

- Develop and manage new onsite veterinary care program including preventive medicine protocols, treatment plans, medical equipment, animal husbandry, bio-security and nutrition.
- Provide routine and emergency care for marine mammals, birds, fish, and marine invertebrates.
- Create and maintain conservation medicine program that involves field and onsite wildlife health research and grant applications, publishing peer-reviewed literature, and performing translational science.
- Perform mammal and bird necropsies and provide training and oversight of fish and invertebrate necropsies.
- Oversee, teach, and train visiting veterinary students and veterinary technicians.

Part-time and Relief Veterinarian, Point Defiance Zoo and Aquarium, Tacoma, WA

2012-2015, part-time

- Provide routine and emergency veterinary care for terrestrial and marine mammals, birds, fish, and elasmobranchs.
- Provide on-call relief and assist with intensive procedures as needed.

Wildlife Epidemiologist and Veterinarian, Lincoln Park Zoo, Chicago, IL

Davee Center for Epidemiology and Endocrinology, 2011, full-time

- Developed and managed new and existing wildlife disease projects in domestic and international field settings.
- Support new and existing captive breeding and reintroduction programs.
- Provide assistance with infectious disease issues and investigate the role of disease in zoo animal health and sustainable zoo populations.

Wildlife Veterinarian, US Fish and Wildlife Service, Honolulu, HI

Palmyra Atoll Rat Eradication, February 2011-August 2011

- Coordinated and executed shorebird mitigation including capture, aviary design and construction, health monitoring, nutrition, and medical care of vulnerable shorebirds in a remote field setting.
- Monitored non-target mortalities and performed necropsies with tissue collection for analysis of anti-coagulants, contaminants, and histological examination.

Wildlife Biologist, USGS National Wildlife Health Center, Madison, Wisconsin

Research Branch under Drs. Franson and Sileo, January 2007-May 2011, part-time

- Designed and participated in research studies including metallic copper toxicity in raptors as an alternative to lead ammunition, avian influenza, lead toxicity, and West Nile virus.
- Trained staff in, and performed, wildlife capture and handling, sample collection, euthanasia, necropsy, and bio-safety level (BSL) 3 laboratory procedures.

UW-Madison, School of Population Health, Master of Public Health Thesis

Master of Public Health Student, January 2009-June 2010

- Acted as lead coordinator to investigate the spatial and temporal dynamics of the sustained high incidence of human West Nile Virus (WNV) infections in North Dakota.
- Collected and analyzed data on human WNV infections and environmental and social variables using geographic information systems (GIS) and Bayesian (WinBUGS) statistics.

National Wildlife Health Center Honolulu Field Station, Honolulu, Hawai'i

Research Assistant to Dr. Thierry Work, Summer 2008

- Performed chelonian, avian, and fish necropsies and fieldwork including coral health transects and ecological field studies.
- Designed and executed a repeatable experimental model for the assessment of disease in coral species under natural or artificial conditions.

University of Wisconsin –Madison, Large Animal Teaching Hospital

Veterinary medical technician, 2005-2007

- Performed physical examinations, administered medications and treatments, and placed intravenous catheters on large animals including horses, cattle, and camelids.
- Assisted with the care of non-ambulatory large animals including transport, sling placement, float tank usage, and emergency stabilization of critically ill patients.

Minnesota Wildlife Rehabilitation Center, Roseville, Minnesota

Wildlife Rehabilitation Intern, Spring/Summer 2005

- Assisted veterinarians with the examination, stabilization, and treatment of various wildlife species.
- Supervised and trained volunteers, organized supplies and fundraising events.

The Raptor Center, University of Minnesota, St. Paul, Minnesota

Raptor Handler, Veterinary Assist, and Education Volunteer, 1995-2002

- Assisted veterinarians with the examination and treatment of various birds of prey.
- Fed and medicated birds and maintained enclosures.
- Presented educational seminars to children and adults on raptor conservation.

The Wildlife Rehabilitation Center, University of Minnesota, St. Paul, Minnesota

Bat and Avian Caretaker, 1997-2000

- Assisted veterinarians with the examination and treatment of various wildlife species with an emphasis on bats and waterfowl species.
- Fed and medicated bats and birds and maintained enclosures.
- Trained new volunteers in safe handling of bats and various aquatic birds.

SKILLS

Exceptional interpersonal and communication skills

Strong technical and scientific background

Highly productive & hardworking

Proven ability to work remotely & independently

Competent and safe animal handler including wildlife and large animals

Fluent in Spanish & basic skills in Japanese

Trained in SAS, GIS, and WinBUGs statistical software

[redacted] [redacted] lesanna.lahner@state.mn.us

PUBLICATIONS

Hewson I, JB Button, BM Gudenkauf, B Miner, AL Newton, JK Gaydos, J Wynne, CL Groves, G Hendler, M Murray, S Fradkin, M Breitbart, E Fahsbender, KD Lafferty, AM Kilpatrick, CM Miner, P Raimondi, **LL Lahner**, CS Friedman, S Daniels, M Haulena, J Marliave, CA Burge, ME Eisenlord, and CD Harvell. 2014. Densovirus associated with sea-star wasting disease and mass mortality. Proceedings of the National Academy of Sciences.

Lahner LL, JC Franson, CU Meteyer, and BA Rattner. 2011. Absence of toxicity of copper pellets simulating oral exposure to bullet and shot fragments in American kestrels (Falco sparverius). Archives of Environmental Contamination and Toxicology.

Mans C, D Guzman Sanchez-Migallon, **LL Lahner**, J Paul-Murphy, and KK Sladky. 2011. Intranasal midazolam causes conscious sedation in Hispaniolan Amazon parrots (Amazona ventralis). Journal of Avian Medicine and Surgery.

Mans C, **LL Lahner**, SM Johnson, and KK Sladky. 2012. Antinociceptive efficacy of buprenorphine and hydromorphone in red-eared slider turtles (Trachemys scripta elegans). Journal of Zoo and Wildlife Medicine.

Lahner LL and Franson JC. Lead Poisoning in Wild Birds. USGS Fact Sheet. November, 2009. http://www.nwhc.usgs.gov/publications/fact_sheets/pdfs/lead_poisoning_wild_birds_2009.pdf

CONFERENCE ABSTRACTS

Lahner LL, JH Breeden, R Breeden, and A. Wegmann. The captive care and treatment of brodifacoum toxicosis in a vulnerable shorebird, the Bristle-thighed curlew (Numenius tahitiensis), during a rat eradication project, Palymyra Atoll, 2011. Accepted for presentation at the American Association of Zoo Veterinarians. Portland, OR. September, 2015.

Lahner LL, S Wahlstrom, A Newton, M Haulena, M Garner and C Mah. Efficacy of intracoelomic enrofloxacin for the treatment of sea star wasting disease in four species of captive asteroidea. Accepted for presentation at the American Association of Zoo Veterinarians. Portland, OR. September, 2015.

Lahner LL, M Murray, J Rasmussen, E Hofmeister, S Wahlstrom, K Roehl, G Sturgeon, M Garner, T Belting, and S Perry. Safety and antibody response to West Nile Virus vaccination in captive sea otters (Enhydra lutris). International Association of Aquatic Animal Medicine, Chicago, IL. April 2015.

Wahlstrom S, **LL Lahner**, A Newton, M Garner, and C Mah. Efficacy of intracoelomic enrofloxacin for the treatment of sea star wasting disease in four species of captive asteroidea. International Association of Aquatic Animal Medicine, Chicago, IL. April 2015.

Lahner LL, A Newton, M Haulena, M Garner, I Hewson. A multidisciplinary investigation of sea star wasting disease. International Association of Aquatic Animal Medicine, Gold Coast, Australia. April 2014.

Lahner LL, T Belting, M Murray. Urolithiasis and perivulvar dermatitis in captive sea otters (Enhydra lutris). Sea Otter Conservation Workshop, Seattle, WA. March 2013.

Lahner LL, S Larson, SM Boutelle. An evaluation of deslorelin implants for contraception in captive sea otters (Enhydra lutris) using fecal gonadal hormone. American Association of Zoo Veterinarians. Oakland, CA. October, 2012.

Lahner LL, C Mans, and KK Sladky. Comparison of route and location of administration for induction of injectable anesthesia in red-eared slider turtles (Trachemys scripta elegans). American Association of Zoo Veterinarians. Kansas City, MO. October, 2011

Lahner LL, Work TH, and Eismueller RL. Health of a Common Scleractinian Coral (Montipora capitata) Under Artificial and Controlled Conditions. European Wildlife Disease Association Student Conference, Veyrier-du-Lac, France. March, 2009

PROFESSIONAL MEMBERSHIPS

- American Association of Zoo Veterinarians (AAZV), Associate Member, 2011-present
- International Association for Aquatic Animal Medicine (IAAAM), 2013-present
- Wildlife Disease Association (WDA), Member, 2011-present
- American Veterinary Medical Assocation (AVMA), Member, 2006 to present
- Association of Zoos and Aquariums (AZA), Professional Affiliate, 2011-2016
- National Wildlife Rehabilitation Association (NWRA), 2016-present
- Wisconsin and Illinois Veterinary Medical Associations, 2010-2012
- Washington State Veterinary Medical Association, 2012-present

PROFESSIONAL CERTIFICATIONS

- Certified Veterinary Acupuncturist (CVA) for large, small and exotic animals.
  The Chi Institute of Traditional Chinese Veterinary Medicine, Reddick, FL. 2009
- USDA Licensed Veterinarian, 2013-present

MICHAEL J. MURRAY DVM

[redacted]

mmurray@mbayaq.org

EDUCATION

Doctor of Veterinary Medicine (DVM), Purdue University, 1977
Pre-Veterinary Curriculum, Purdue University, 1971-1973

Professional Licenses

Veterinary Medicine, Dentistry, and Surgery, California
Veterinary Medicine, Dentistry, and Surgery, Indiana
USDA Accredited Veterinarian

Professional Affiliations

Research Associate, University of California, Santa Cruz
Advisor, Accreditation Commission, Association of Zoos and Aquariums
Editorial Review Board, Journal of Zoo and Wildlife Medicine
Editorial Review Board, Journal of Avian Medicine and Surgery
Editorial Review Board, Seminars in Avian & Exotic Pet Medicine, WB Saunders, Co., 2000-2012
Editorial Review Board, Compendium on Continuing Education for the Practicing Veterinarian, 1999-2007
Member, Animal Health Committee, Association of Zoos and Aquariums, 2005-2011
Associate Editor, Journal of Avian Medicine and Surgery, 1995 - 1999
Session Chair, Small Mammal Program, North American Veterinary Conference, 2003 – 2006

HONORS AND AWARDS

US Army Health Professions Scholarship, 1973-1977
Phi Zeta, Veterinary Scholastic Honor Society
US Army Medical Department Veterinary Officer's Course Commandant's List, 1977
US Army Commendation Medal, 1979, 1980
US Army Meritorious Service Medal, 1983
Monterey County Society for the Prevention of Animals Humanitarian of the Year, 1986, 2001
Speaker of the Year for the Exotic Animal Program, North American Veterinary Conference, 2001
Exotic DVM of the Year, 2002
Association of Zoos & Aquariums, Inspector of the Year, 2011
Text and Academic Authors Association, Texty Excellence Award, 2012
Association of Zoos & Aquariums, Outstanding Service Award, 2012

EXPERIENCE

Monterey Bay Aquarium
Director of Veterinary Services
1988 to present
Duties include provision of on-site and on-call veterinary support for all exhibit animals, including exhibit Southern sea otters. Additional responsibilities include veterinary support for orphaned and injured wild Southern sea otters, which may be admitted by the Monterey Bay Aquarium's Sea Otter Research and Conservation Program. Additionally, liaison is maintained with, and veterinary medical and surgical

support provided to a number of outside private and government agencies involved in management and research associated with the Southern sea otter. This position became a full-time position on 1 April 2004.

Avian & Exotic Clinic of the Monterey Peninsula
Founder and Staff Veterinarian
1989 to 2004
A private veterinary practice with a caseload consisting exclusively of avian and exotic patients; approximately 40% avian, 20% reptile, 30% small mammal (not dog/cat), and 10% others (fish, invertebrates) averaging 80-100 cases per week.

Antech Diagnostics
Avian & Exotics Consultant
1999 to 2010
One of several veterinarians contracted with a private veterinary diagnostic laboratory as avian and exotic animal clinical consultants. As such, provides telephonic consultation to lab client veterinarians requesting assistance in case management or interpretation of clinical laboratory data.

Ventana Wilderness Society
Consulting Veterinarian
1986 to present
Responsibilities include providing medical and surgical care for a non-profit organization, which is involved in the translocation and re-introduction of endangered species. Thus far, the program has successfully re-established breeding pairs of bald eagles in central California and is currently one of the three field sites for re-introduction of the California condor.

Monterey County SPCA Wildlife Rehabilitation Center
Staff Veterinarian
1981 to 2004
Responsible for the provision of medical and surgical care for injured and orphaned native species of birds, mammals and reptiles.

Santa Cruz Predatory Bird Group
Consulting Veterinarian
1989-1993
Provided on-call and on-site support for the University of California at Santa Cruz project responsible for the monitoring, nest management, hack site manipulation, and cross fostering of peregrine falcons. Project discontinued as the mandated number of successful breeding pairs had been established.

Coast Veterinary Hospital
Associate Veterinarian
1983-1989
Duties included all aspects of veterinary medicine, dentistry, and surgery in an American Animal Hospital Association accredited companion animal hospital. Resigned to found the Avian & Exotic Clinic of the Monterey Peninsula.

US Army Veterinary Corps
Veterinary Officer, Captain
1977-1983
Responsible for personnel management, food hygiene and quality assurance, military working dog health, and zoonoses control on military installations. Duty assignments included Los Angeles, CA; Ft Ord, CA, and 106th Medical Detachment, Taegu, Republic of Korea. Established a program for the monitoring of diseases in wildlife populations on military installations controlled by Ft. Ord.

PROFESSIONAL AFFILIATIONS

American Veterinary Medical Association

Monterey Bay Area Veterinary Medical Association
President, 1991-1992
Association of Avian Veterinarians
Director, 1992-1995
American Association of Zoo Veterinarians
Association of Reptile and Amphibian Veterinarians
International Association of Aquatic Animal Medicine
Association of Zoos & Aquariums
Wildlife Disease Association

PUBLICATIONS, Primary Author

"Veterinary Medicine and Sea Otter Conservation". In Sea Otter Conservation, Larson SE, Bodkin JL, VanBlaricom GR (eds), Academic Press, San Diego, CA, 2015, pp 160-197.

"Euthanasia" In Invertebrate Medicine, 2nd Ed, Lewbart, GR (ed), Wiley-Blackwell, Ames, IA, 2012, pp 441-443.

"Endoscopy in Sharks" Veterinary Clinics North America Exotic Animal Practice 13(2):301-313, 2010

"Invertebrates" In Guidelines for Euthanasia of Nondomestic Animals, American Association of Zoo Veterinarians, 2006, pp 25-27.

"Sea Otters" In Guidelines for Euthanasia of Nondomestic Animals, American Association of Zoo Veterinarians, 2006, pp 75-77.

"Euthanasia" In Invertebrate Medicine, Lewbart, GA, Blackwell Publishing, Ames, IA, 2006, pp 303-304.

"Pneumonia and Lower Respiratory Tract Disease". In Reptile Medicine and Surgery, 2nd Ed, Mader, DR (ed), Saunders, Elsevier, St. Louis, 2006, pp 865-877.

"Aural Abscesses". In Reptile Medicine and Surgery, 2nd Ed, Mader, DR (ed), Saunders, Elsevier, St. Louis, 2006, pp 742-746.

"Cardiology". In Reptile Medicine and Surgery, 2nd Ed, Mader, DR (ed), Saunders, Elsevier, St. Louis, 2006, pp 181-195.

"Cardiopulmonary Anatomy and Physiology". In Reptile Medicine and Surgery, 2nd Ed, Mader, DR (ed), Saunders, Elsevier, St. Louis, 2006, pp 124-134.

"Reptilian Blood Sampling and Artifact Considerations" In Laboratory Medicine Avian and Exotic Pets, Alan Fudge, editor. WB Saunders Co, Philadelphia, 2000, pp 185-192.

"Rabbit and Ferret Sampling and Artifact Considerations" In Laboratory Medicine Avian and Exotic Pets, Alan Fudge, editor. WB Saunders Co, Philadelphia, 2000, pp 265-268.

"Endoscopic Surgery". Co-editor with Michael Taylor; Seminars in Avian and Exotic Pet Medicine, WB Saunders Co, Philadelphia, 8(3), 1999.

"Avian Renal Disease: Endoscopic Applications" Co-author with Michael Taylor; Seminars in Avian and Exotic Pet Medicine, WB Saunders Co, Philadelphia. 8(3):115-121, 1999.

"Endoscopic Examination and Therapy of the Avian Gastrointestinal Tract". Co-author with Michael Taylor; Seminars in Avian and Exotic Pet Medicine, WB Saunders Co, Philadelphia. 8(3):110-114, 1999.

"Highlights and Horizons: Exotic Animal Medicine" Compendium on Continuing Education for the Practicing Veterinarian, Trenton, NJ. 21(3):194-195/266, 1999.

"Endoscopy in Birds, Reptiles, Amphibians and Fish" Co-author with Bernd Schildger and Michael Taylor. Endo-Press, Tuttlingen, Germany. 1999.

"Diagnostic Techniques in Avian Medicine" Seminars in Avian and Exotic Pet Medicine, WB Saunders Co, Philadelphia. 6(2):48-54, 1997.

"Cardiology and Circulation" In Reptile Medicine and Surgery, Douglas Mader, editor. WB Saunders Co, Philadelphia, 1996, pp 95-104.

"Aural Abscesses" " In Reptile Medicine and Surgery, Douglas Mader, editor. WB Saunders Co, Philadelphia, 1996, pp 349-352.

"Pneumonia and Normal Respiratory Function" " In Reptile Medicine and Surgery, Douglas Mader, editor. WB Saunders Co, Philadelphia, 1996, pp 396-405.

"Soft Tissue Surgery", editor. Seminars in Avian and Exotic Pet Medicine, WB Saunders Co, Philadelphia, 2(2), 1993.

PUBLICATIONS, co-author

Shapiro K, Miller MA, Packham AE, Aguilar B, Conrad PA, VanWormer E, **Murray MJ**, Dual congenital transmission of *Toxoplasma gondii* and *Sarcocystis neurona* in a late-term aborted pup from a chronically infected southern sea otter (*Enhydra lutris nereis*), *Parasitology* 143: 276-288, 2016.

Thometz NM, **Murray MJ**, Williams TM, Ontogeny of oxygen storage capacity and diving ability in the southern sea otter (*Enhydra lutris nereis*): costs and benefits of large lungs, *Physiological and Biochemical Zoology* 88(3):311-27, 2015.

Hewson I, Button JB, Gudenkauf BM, Miner B, **Murray M**, et al, "Densovirus associated with sea-star wasting disease and mass mortality, *Proceedings of the National Academy of Science USA*, 111(48): 17278-83, 2014.

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Lander, ME, Westgate, AJ, Bonde, RK, **Murray, MJ**. "Tagging and Tracking" in CRC Handbook of Marine Mammal Medicine, 2nd Ed, Dierauf, LA and Gulland FMD (eds). CRC Press, Boca Raton, FL, 2001, pp 851-880.

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Miller, MA, Crosbie, PR, Gardner, IA, Barr, BC, Lowenstine, LJ, Gulland, FM, **Murray, M**, Jessup, D, Conrad, PA. "An update on protozoal brain infections in harbor seals (Phoca vitulina richardsi) and southern sea otters (Enhydra lutris nereis) in California. 13th Joint US-Russia Sea Otter Workshop, Monterey, CA. November, 2000.

Staedler M, Johnson AB, Hymer JA, **Murray MJ**: The Monterey Bay Aquarium's sea otter research and conservation program; 1984-1998.   Sea Otter in Zoos and Aquariums Consortium, Seattle, WA, 1999.

Sousa M, Giles A, Jeffries M, **Murray MJ**: Living on the edge: the challenges of elevated coliform bacteria levels in a "living" exhibit. International Marine Animal Trainers Association Annual Conference, Albufeira, Portugal, 1998.

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(a) Academic training:

UNH	Wildlife Management	B.S.	1984
UNH	Animal Science (Wildlife Emphasis)	M.S.	1990
UC Davis	Veterinary Medicine	D.V.M.	1994
North Carolina State	Medicine and Surgery	Internship	1995
UC Davis	Anatomic Pathology	Residency	1996
UC Davis	Anatomic Pathology	Instructorship	1998
UC Davis	Comparative Pathology	Ph.D.	2002

(b) Employment:

1999-Present: WILDLIFE VETERINARIAN SPECIALIST/ PATHOLOGIST. **Marine Wildlife Veterinary Care and Research Center, California Department of Fish and Wildlife, Office of Spill Prevention and Response, Santa Cruz, CA 95060.** Oversee statewide marine wildlife necropsy program. Served as facility director 2010-2011. Provide expertise for forensic cases, oil spill & outbreak investigation, policy planning & program development. Conduct complex environmental health research, present findings and prepare and submit scientific publications & grant proposals. Negotiate and administer contracts. Train and oversee laboratory staff, visiting scientists and graduate students. Maintain non-salaried staff appointment at UCD and oversee UCD-based grants. Represent CDFW in official capacity to facilitate interactions with other agencies, policymakers, the public and press. Coordinate tests, complete microscopic examinations & prepare reports.

1995-1999: PATHOLOGY RESIDENT & PATHOLOGY GRADUATE ACADEMIC FELLOWSHIP. **Veterinary Medical Teaching Hospital, U.C. Davis, CA 95616.** Supervised and taught veterinary students and graduate students in the classroom and necropsy facility. Designed, funded and completed PhD dissertation research on *Toxoplasma gondii* and *Sarcocystis neurona* infections in marine species. Helped develop and validate serodiagnostic tests that are in wide use for marine wildlife. Completed advanced coursework in general pathology, immunology and cell and molecular biology. Performed necropsies on small animals, livestock, primates, reptiles, amphibians, free-living wildlife and zoo animals.

1996: PATHOLOGIST (CONTRACT). **Colorado Parks and Wildlife, Fort Collins, Colorado, 80526.** Under contract with Colorado Parks and Wildlife, evaluated formalin-fixed brain & lymph nodes collected from hunter-killed deer and elk from Colorado for lesions consistent with chronic wasting disease (CWD) and bovine tuberculosis. Compiled findings into a summary report & highlighted suspect cases for subsequent confirmatory testing. Helped prepare a summary abstract for a presentation at the annual Wildlife Disease Association meeting. Completed a residency project on chronic wasting disease in deer and elk. Trained under Dr Beth Williams from the Wyoming Veterinary Diagnostic Laboratory for CWD diagnosis.

1994-1995: SMALL ANIMAL CLINICAL MEDICINE AND SURGERY INTERN. **North Carolina State School of Veterinary Medicine. Raleigh-Durham North Carolina 27607.** Responsible for clinical case management, client communication, off-hours emergency duty & veterinary student supervision & training. Specialty training through clinical rotations in Emergency Medicine, Soft Tissue Surgery, Orthopedics, Radiology, Cardiology, Neurology, Dermatology, Oncology, Critical Care & Shelter Medicine. Responsible for providing critical care for all hospitalized animals during off hours. Interacted with referring veterinarians & clients. Fielded calls & questions from the general public and other institutions. Completed research on the disease Rocky Mountain Spotted Fever, & presented findings to NCSU faculty, staff & students.

(c) Specialized training:

- 2017: 24 h HAZWOPER, ICS 100, ICS 200 renewal, core OWCN training
- 2017: Participated in meeting with OWCN to review sea otter spill response protocols
- 2017: Editorial review of sea otter necropsy protocols/forms to facilitate spill response
- 2017: California Veterinary Medical Reserve Corps (CAVMRC) training/ certification
- 2014: Introduction to Forensics: New Mexico Veterinary Diagnostic Laboratory
- 2014: Introduction to Animal Restraint, CDFW-WIL
- 2009: CYANOHABS: 2 day course on cyanobacterial ID, toxin detection and water quality
- 2008: General Pathology-5 day intensive review of gross pathology conducted by the Armed Forces Institute of Pathology (AFIP) and the Charles Louis Davis (CL Davis) Foundation
- 2008: Descriptive Pathology-5 day intensive review of histopathology, cytology, electron microscopy immunohistochemistry and gross pathology conducted by AFIP and CL Davis
- 2005 and 2009: Preparing for and surviving court testimony, CDFW
- 1991 and 2000: Introductory and Advanced Foreign Animal Disease Diagnostic Training: USDA-APHIS Foreign Animal Disease Diagnostic Laboratory, Plum Island, New York
- 1997 & 2000: Introduction to Wildlife Forensics-R. Stroud, National Wildlife Forensic Lab.
- 1996-1997: Contract Pathologist, Colorado Division of Wildlife-Interpreted slides prepared from deer and elk for lesions consistent with chronic wasting disease and tuberculosis. Trained by Dr Beth Williams.
- Veterinary accreditation training, ACVP Board-eligible, DEA certification and licensure, media response training (UC Davis), basic chemical restraint for wildlife, basic hunter safety training, first aid, CPR.

(d) Service Appointments:

• UC Davis Wildlife Health Center	Senior Staff (NSR)	2011-Present
• The Marine Mammal Center, Marin, CA	Science Advisory Panel	2011-Present
• California Department of Fish and Wildlife	Veterinarian	1999-Present
• UC Davis Wildlife Health Center	Staff Vet./Student	1999-2004
• UCD Dept. of Pathol., Microbiol. & Immunol.	Instructor	1997-1999
• Vet. Pathol., J Wildl. Dis., Dis. Aquat. Org.	Invited editor	Ongoing

(e) Honors, awards and accomplishments:

- <u>2018: Recipient, CDFW 2018 Group Employee Excellence Award for Partnership</u> as a member of the OSPR Marine Wildlife Veterinary Care and Research Center Team
- 2018: Invited Speaker, Stanford University Medical School, Palo Alto, CA: Land-sea pollution
- 2018: Invited speaker, CL Davis Pathology Session at International Association for Aquatic Animal medicine meeting, Long Beach, CA-Coccidioidomycosis (Valley fever)

- 2018: Presenter, International Association for Aquatic Animal medicine meeting, Long Beach, CA-15 year sea otter pathology and risk factor study
- <u>2017: Plenary Speaker-CDFW Science Symposium</u>
- 2017: Invited Speaker and Panelist, UC Davis One Health Symposium
- 2017: Invited Speaker, Stanford University Medical School, Palo Alto, CA: Biological pollution
- <u>2016: Recipient, Individual award for scientific excellence, CDFW</u>
- <u>2016: Nominee-CDFW group excellence award for response effort during Refugio Oil Spill</u>
- 2016: Linda Munson Award-Provided mentorship and support for recipient of best student-led wildlife pathology manuscript award in Journal of Wildlife Disease and Journal of Zoo and Wildlife Medicine for 2016. Another student mentee was also a finalist.
- 2016: Invited Speaker, Wetlab Instructor-NOAA National Marine Mammal Stranding Meeting
- 2016: Featured Scientist-"Heirs to our Oceans" documentary series
- 2016: Invited Speaker-Western Section of the Wildlife Society
- 2015: Research findings stimulated creation of bill for California statewide cyanotoxin monitoring program (sponsored by Senator Bill Monning and Assembly Members Mark Stone and Luis Allejo)
- 2015: Invited Speaker-*Toxoplasma*-Stanford University Medical School, Palo Alto, CA
- 2015: Invited Speaker-Cyanotoxin Summit and Statewide Webinar-CDPH, Richmond, CA
- 2015: Invited Speaker-OWCN Science Symposium, UCD School of Veterinary Medicine
- 2014 Invited Speaker-Wildlife Disease Association, New Mexico
- 2014: Cover article-May, 2014 issue of PLoS Neglected Tropical Diseases
- 2014: Invited Speaker (*Toxoplasma*)-Zoobiquity Conference, Stanford Medical School
- 2013: Invited external reviewer-Surface Water Ambient Monitoring Program (SWAMP) Monitoring Plan for Cyanotoxins in Lakes/Reservoirs and Coastal Wetlands, CA,
- 2013: Keynote Speaker-Pathology Special Session-IAAAM, Marin, CA
- 2012: Invited speaker-California Cooperative Oceanic Fisheries Investigations (CalCOFI) "Harmful Algal Blooms in the California Current", Asilomar, CA
- 2012: Invited Speaker-SWRCB cyanotoxin workshop, Oakland, CA
- 2012: Research findings on land-sea flow of freshwater cyanotoxins helped prompt consideration of Pinto Lake as a site for focused remediation by the United States Environmental Protection Agency
- 2012: Invited Speaker/Panelist-AAAS Special Session-Swimming in Sick Seas, Vancouver
- 2012: Ocean Ecosystem Workgroup Member-California Water Quality Monitoring Council
- 2012: Appointed to Scientific Advisory Panel, The Marine Mammal Center, Marin, CA
- 2011: Appointed to Senior Scientific Staff-Wildlife Health Center, UCD School of Vet. Med.
- 2011: Research findings prompted declaration of total daily maximum loads (TMDLs) for microcystin discharge at Pinto Lake by Central Coast Regional Water Control Board
- 2011: Invited Speaker-Workshop on Cyanobacteria and Human Health: Merging Ecology, Epidemiology and Neurologic Disorders. Bowdoin College, Maine
- 2011: Cover article, Spring 2011 issue of Journal of Wildlife Disease
- 2010: Most cited manuscript: 2007-2010. International Journal for Parasitology
- 2009: Invited speaker-Fall, 2009 American College of Veterinary Pathology
- 2009: Invited speaker-Fall, 2009 The Wildlife Society
- 2008: Cover article, fall, 2008 issue of International Journal of Parasitology
- 2006: Research findings helped stimulate passage of CA Assembly Bill 2485 (enhanced enforcement potential for pollution crimes against mammals in California)
- 2002: Research Fellow-Morris Animal Foundation

- 2002: Best Manuscript Award-American College of Zoological Medicine
- 2001: Graduate Student Research Award-Wildlife Disease Association
- 1998: Research Fellow-Lindbergh Foundation
- 1998: Wildlife Disease Association Scholarship
- 1997: C.L. Davis DVM Foundation-Student Scholarship Award in Pathology
- 1994: Eirene Ritchie-Hill Memorial Scholarship for Wildlife Health
- 1994: Wilds Award for Achievement in Academics and Research
- 1994: Merck Veterinary Manual Achievement Award

(f) Press interactions:

Research efforts highlighted in:

Newspapers: Los Angeles Times, New York Times, Wall Street Journal, San Francisco Chronicle, Sacramento Bee, Chicago Tribune, San Jose Mercury News, Monterey Herald, local/ regional papers

Magazines and periodicals: National Geographic, Scientific American, JAVMA, JVDI, Discover Magazine, New Scientist, Ladies Home Journal, Surfrider Magazine, Morris Animal Foundation News.

Radio/ television: PBS, Discovery Channel, National Geographic (evening news and Earth Pulse), QUEST (KQED). NPR (Todd Mundt Show), Earthwatch Radio, numerous regional and local programs

(g) Student mentorship:

Postdoctoral:

UCSF: T. Fei Fan Ng
U. WY: E. Gagne

PhD:

UCD: C. Johnson, W. A. Miller, D. Rejmanek, H. Dabritz, K. Wainwright, K. Counihan-Edgar, E. VanWormer, J. Hogan, R. Stoddard, K. Hanni, S. Carrasco, D. Imai, A. Schriever, T. Burgess, M. Moriarty, R. Pesapane, R., P. Sebastian, R. Bong, A. Guimera
UCSC: C. Gibble
Stanford: R. Grewelle
University of Alberta: K. Shanebeck

MS/MPVM:

UCD: K. Shapiro, L. Godoy
UCSC: F. Batac
CSU-MLML: E. McHuron, K. Mayer
CSU-MB: M. Daniels
Tufts: L. de Whit
Royal Veterinary College, London: A. Coup
U. Hanover (Germany): K. Shanebeck
U. Wyoming: N. Carter

DVM:

UCD: H. Harris, C. Stavely, A. Fisher, A. Parker, A. Capuano
U. Washington: A. Schneider

Cornell: S. Huckabone
Tufts: K. Alroy
University of Liverpool: G. Bartlett
The Ohio State University: C. Shockling-Dent

Undergraduate:
UCSC: S. Chinn
UCD: N. Javeed
U. Northern Florida: A. Brown

Senior Veterinary Students:
Initiated development of a CDFW/UC Davis wildlife veterinary externship/training program with Dr Jonna Mazet, the Director of the UC Davis Wildlife Health Center around 2000. To date, we have co-mentored >50 senior vet externs as part of an 20 year collaboration between CDFW-WIL, CDFW-OSPR, and UCD. Several of our past externs are now nationally and internationally recognized wildlife veterinarians.

(h) Manuscripts, book chapters, articles and other products:

(In review) Burgess TL, Tinker MT, **Miller MA**, Smith WA, Bodkin JL, Murray MJ, Nichol LM, Saarinen JM, Larson S, Tomoleoni JA, Conrad PA, Johnson CK. Spatial epidemiological patterns reveal mechanisms of land-sea transmission for *Sarcocystis neurona* in a coastal marine mammal. Nature Scientific Reports.

(In review) **Miller MA**, Duignan P, Dodd E, Batac F, Staedler M, Tinker MT, Murray M, Henkel L, Gardiner C. Emergence of a zoonotic pathogen in a coastal marine sentinel: *Capillaria hepatica* (syn. *Calodium hepaticum*)-associated hepatitis in southern sea otters (*Enhydra lutris neries*). J Wildl Dis.

(In press) Shockling Dent CE, **Miller MA**, Batac FI, Dodd E, Smith W, Pesapane R, Foley J. Pathology and epidemiology of nasopulmonary acariasis (*Halarachne* sp.) in southern sea otters (*Enhydra lutris nereis)*. IJP: PAW.

2019 Volokhov DV, Batac FI, Gao Y, **Miller MA,** Chizhikov VE. *Mycoplasma enhydrae* sp. nov. isolated from California sea otters *(Enhydra lutris nereis).* Int. J Syst Evolut Microbio. 69: 363-370, doi: 10.1099/ijsem.0.003144.

2018 Pesapane R, Dodd E, Javeed N, **Miller MA**, Foley J. Molecular characterization and prevalence of *Halarachne halichoeri* in threatened southern sea otters (*Enhydra lutris nereis*). IJP:PAW. https://doi.org/10.1016/j.ijppaw.2018.09.009.

2018 **Miller MA,** Raverty S, Shapiro K. Invited Author: Chapter 40-Marine Mammal Protozoa. *IN* CRC Handbook of Marine Mammal Medicine: Health, Disease, and Rehabilitation. Third Edition. L Dierauf, FM Gulland, & KI Whitman, Eds. CRC Press.

2018 Williams B, Burek-Huntington K, **Miller MA**. Diseases of Mustelids. Chapter 11. *IN* Pathology of Wildlife and Zoo Animals. Irst. Edit. K Terio, D McAloose and J St. Leger, Eds. Academic Press. Pp. 287-304.

2018 Burgess T, Tinker MT, **Miller MA**, Bodkin J, Murray M, Saarinen J, Conrad P, Johnson C. Defining the risk landscape in the context of pathogen pollution: *Toxoplasma gondii* in sea otters along the Pacific Rim. Royal Soc Open Sci. https://doi.org/10.1098/rsos.171178.

2018 Brown A, Foss A, **Miller MA**, Gibson QA. Detection of cyanotoxins (microcystins/nodularins) in livers from estuarine and coastal bottlenose dolphins (*Tursiops truncatus*) from Northeast Florida. Harmful Algae. DOI: 10.1016/j.hal.2018.04.011

2018 Gagne R, Tinker MT, Ralls K, Larson S, Tarjan LM, **Miller MA**, Ernest HB. Measures of effective population size in sea otters reveal special considerations for wide-ranging species. Evolutionary Applications. DOI: 10.1111/eva.12642

2017 Capuano AM, **Miller MA**, Stallknecht DE, Moriarty M, Plancarte M, Dodd E, Batac F, Boyce WM. Serologic Detection of Subtype-specific Antibodies to Influenza A Viruses in Southern Sea Otters (*Enhydra lutris nereis*). J Wildl Dis.53: 906-910. doi: 10.7589/2017-01-011.

2017 **Miller MA**, Burgess T, Dodd E, Ewalt D, Nielson K., Rhyan J, Jang S, Byrne B., Gulland F, Murray M, Smith W. Erratum: Isolation and characterization of a novel marine *Brucella* from a southern sea otter (*Enhydra lutris nereis*), California, USA. J Wildl Dis.

2017 Oates SC, **Miller MA**, Hardin D, Dominik C, Jessup D, Smith WA. Estimating daily relative dog abundance, fecal density and loading rates on two marine recreational beaches in Monterey County. Mar Pollut Bull. 125: 451-458. doi: 10.1016/j.marpolbul.2017.10.062.

2017 **Miller MA**, Moriarty ME, Dodd EM, Burgess T, Tinker MT, Batac FI, Henkel LA, Young C, Harris MD, Kreuder-Johnson C. 2017. The dead do tell tales: Investigating sea otter mortality patterns (1998-2012). Unpublished final report to California Coastal Conservancy, Oakland, CA. 156 pp.

2017 Young C, **Miller MA**, Newsome SD Dailey M. First report of intestinal cestodiasis in a southern sea otter. J Wildl. Dis. DOI: 10.7589/2017-01-020.

2017 **Miller MA**, Burgess T, Dodd E, Ewalt D, Nielson K, Rhyan J, Jang S, Byrne B, Gulland F, Murray M, Smith W. Isolation and characterization of a novel marine *Brucella* from a southern sea otter (*Enhydra lutris nereis*), California, USA. J Wildl. Dis. DOI: 10.7589/2015-12-326

2017 Shen Z, Batac F, Mannion A, **Miller MA**, Bakthavatchalu V, Ho C, Manning S, Paster BJ, Fox JG. Novel *Helicobacter* sp., '*H. enhydrae* sp. nov.' isolated from gastric tissue of Southern sea otters. Dis. Aquat. Organ. 123: 1-11. doi: 10.3354/dao03082.

2017 Siqueira J, Ng T, **Miller MA**, Li L, Deng X, Dodd E, Batac F, Delwart E. Endemic infection of stranded Southern sea otters (*Enhydra lutris nereis*) with novel parvovirus, polyomavirus and adenovirus. J Wildl. Dis. 53: 532-542. doi: 10.7589/2016-04-082.

2016 Lee B, Byrne BA, Young MA, Murray MA, **Miller MA**, Tell L. Pharmacokinetic parameters for adult southern sea otters (*Enhydra lutris nereis*) following a single subcutaneous dose of cefovecin sodium. J. Vet. Pharmacol. Therap. 39: 625-628.

2016 Ferguson SD, Wellehan JF, Frasca S, Innis CJ, Harris H, **Miller MA**, Weber E, Stockdale S, Walden H, Greiner EC, Merigo C, Stacy BS. Coccidial infection of the adrenal glands of leatherback sea turtles (*Dermochelys coriacea*). J Wildl. Dis. DOI 10.7589/2015-11-310.

2016 Lee EA, Byrne BA, Young MA, Murray M, **Miller MA**, Tell L. Pharmacokinetic parameters of cefovecin in adult sea otters *(Enhydra lutris).* J Vet. Pharmacol. Therap. doi: 10.1111/jvp.12322.

2016 Backer L, **Miller MA.** Applying a One Health Approach to Biotoxin Monitoring: Animals as Sentinels for Harmful Cyanobacteria and Algae Blooms. Vet. Sci. doi: 10.3390/vetsci3020008.

2016 Chinn S, **Miller MA**, Staedler M, Tinker M, Harris MD, Batac F, Dodd E, Henkel L. The high cost of motherhood: End-lactation syndrome (ELS) in southern sea otters (*Enhydra lutris nereis*). J Wildl. Dis. http://dx.doi.org/10.7589/2015-6-158. <u>Finalist: Linda Munson Award for best student wildlife disease manuscript for 2016 in the Journal of Wildlife Disease and Journal of Zoo and Wildlife Medicine</u>

2016 Bartlett B, Miller W, Dominik C, Batac F, Dodd E, Byrne B, Jang S, Jessup D, Chantrey J, **Miller MA.** Prevalence, pathology and potential risk factors associated with *Streptococcus phocae* infection in southern sea otters (*Enhydra lutris nereis*) (2004-2010). J Wildl. Dis. 52: 1-9. <u>Recipient: Linda Munson Award for best student wildlife disease manuscript for 2016 in the Journal of Wildlife Disease and Journal of Zoo and Wildlife Medicine</u>

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1990 **Chechowitz (Miller) MA.** Master's Thesis. Aspergillosis in common eiders (*Somateria mollissima*). University of New Hampshire.

1989 Pinkerton KE, Kendall JZ, Randall GC, **Chechowitz (Miller) MA**, Hyde DM, Plopper CG. Hypophysectomy and porcine fetal lung development. Am. J. Respir. Cell. Mol. Biol. 1989 1: 319-28.

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<u>EDUCATION</u>:

- Master of Arts (MA) Ecology and Evolutionary Biology University of California, Santa Cruz, 2011
- Sampling and Experimental Design Moss Landing Marine Laboratories, 1997
- Bachelor of Arts (BA) Environmental Studies with Marine Science emphasis, University of California, Santa Cruz, 1986

<u>WORK EXPERIENCE</u>:

Monterey Bay Aquarium
Sea Otter Program Manager
May 2018 - Present
This position leads the sea otter team in Conservation Research by; (i) overseeing stranding response, animal care, surrogacy, and reintroduction operations; (ii) managing research and scientific content generation; (iii) coordinating internally with other related Aquarium departments; (iv) and maintaining collaborative relationships with external partners in governmental agencies, NGOs, other zoos and aquariums, and universities; and (vi)responsible for program budget

Monterey Bay Aquarium
Sea Otter Research Coordinator
August 1996 - April 2018
Duties include managing two to three staff, and training interns and up to 30 volunteers on collaborating research projects with our Sea Otter Alliance partners. Maintain various databases, analyze data and prepare manuscripts for publication. Additionally, prepare posters or spoken presentations for scientific, lay, and educational venues. Conduct research and oversee sea otter research projects that Monterey Bay Aquarium is participating in. Design and implement a research project for Monterey Bay Aquarium's "Project White Shark". Other duties include assisting students on research projects, and conducting media interviews when requested by the PR department.

Monterey Bay Aquarium
Senior Research Assistant
July 1993- July 1995
Field observations of wild and rehab sea otters, maintain various data bases, supervise volunteers, helped prepare manuscripts for publication, and help prepare posters and talks for conferences. In addition to above activities, also design research projects for the exhibit and rehab otters at the aquarium. Conduct interviews with media; work in conjunction with the Oiled Wildlife Care Network and the USFWS Sea Otter Stranding Network. Prepare and manage budget. Designated liaison for MBA with other institutions studying sea otters. Plan and organize workshops for volunteers.

Monterey Bay Aquarium
Part Time Gift and Bookstore Sales Person
July 1986 - July 1987
Tasks included working as a sales person in bookstore handling large sums of money and a variety of merchandise items along with interacting with visitors.

Monterey Bay Aquarium
Research Assistant
July 1986 - July 1993
Field observations of wild sea otters, maintained data bases, supervised volunteers, helped prepare manuscripts and posters for conferences.

Año Nuevo State Reserve, San Mateo CA
Park Interpretive Specialist
1984 - 1986
Worked in various aspects of State Parks, including Park Interpretive Specialist in which I was responsible for seeing that groups of people safely begin the second leg of their natural history tour. I provided natural history and biology interpretation of the State Park and resident elephant seals.

Año Nuevo State Reserve, San Mateo CA
State Park Intern and Natural History Interpreter
1983 - 1984
In charge of getting groups of 20 people organized and ready to begin the first stage of natural history walk. I was responsible for sales in the interpretive bookstore and operation of the store.

University of California, Santa Cruz, CA
Ocean Education Coordinator
1982 - 1983
My responsibilities included setting up and running the outreach program, hiring student interns, supervised their work, and coordinated school groups for tidepool tours at Natural Bridges State Park.

Details:

PROFESSIONAL MEMBERSHIPS

- Marine Mammal Society:
  Member since 1994

- Russian/American Sea Otter Working Group:
  Member since 1989

- Oiled Wildlife Care Network
  Member since 1989

PUBLICATIONS & PRESENTATIONS

Nicholson, T. E., Mayer, K. M., **Staedler, M. M.,** Fujii, J. A., Murray, M. J., Johnson, A. B., Tinker, M. T., Van Houtan, K. S., (2018). Gaps in kelp cover may threaten the recovery of California sea otters. *Ecography 41*; 1-12

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Research Interests

Animal Ecology, Animal Eco-Physiology, Historical Ecology, Conservation Biology

Education

2000–2005 Ph.D., University of California Santa Cruz (Santa Cruz, CA)
Earth & Planetary Sciences Department

1995–1999 B.A., Dartmouth College (Hanover, NH)
Earth Sciences Department

Positions & Professional Development

2018– *Associate Professor*, Biology Department, University of New Mexico (Albuquerque, NM)

2014– *Associate Director,* University of New Mexico Center for Stable Isotopes

2013–2018 *Assistant Professor*, Biology Department, University of New Mexico (Albuquerque, NM)

2009–2012 *Post-Doctoral Research Scientist*, University of Wyoming (Laramie, WY)
Research focused on (1) using compound specific stable isotope analysis to quantify protein routing in mammals, birds and fish; (2) characterizing the ecology of an adaptive radiation in a group of South American songbirds via biochemical, physiological, and genetic tools. Advisors: Drs. Carlos Martinez del Rio and David G. Williams

2006–2009 *Post-Doctoral Research Scientist*, Carnegie Institution of Washington (Washington, DC)
Research focused on (1) development of stable isotope methods to assess ecological niche and eco-physiological variation, foraging specialization, and dispersal characteristics of mammals and birds; (2) human impacts on ecosystem change in Australia and southern California.
Advisor: Dr. Marilyn L. Fogel

2000–2005 *Ph.D. Candidate*, UC-Santa Cruz (Santa Cruz, CA)
Research focused on historic and prehistoric ecology of marine mammals, with emphasis on the northern fur seal in the northeast Pacific Ocean.
Advisor: Dr. Paul L. Koch

2000 *Senior Lab Technician*, Lawrence Berkeley National Laboratory (Berkeley, CA)
Managed stable isotope facility and conducted research using isotopic tracers to track fluid and contaminant migration through sediments and groundwater.
Advisor: Dr. Mark E. Conrad

1998–1999 *Senior Honors Thesis,* Dartmouth College (Hanover, NH)

Grants (2006–2019)

2019 National Science Foundation: Biological Oceanography [redacted], pending)
“Heat, hydrodynamics, and heterotrophy: investigating the role of food supply in coral resilience to ocean warming”
Co-PI with Drs. Anne Cohen and Michael Fox (WHOI)

2019 National Science Foundation: Systematics and Biodiversity Science [redacted]0, pending)
“Small mammal microbiomes, arthropods, and helminths (SMASH)”
Co-PI with Drs. Joe Cook (UNM), Steve Greiman (GSU), and Derek Sikes (UAF)

2019 National Institutes of Justice: Biological Oceanography [redacted], pending)
“Compound-specific stable isotope analysis of human keratin tissues for migration and region of origin determination”
Co-PI with Dr. Christy Mancuso (UNM)

2018 FONDECyT–Chile [redacted])
“Using stable isotope values of prehistorical and contemporary marine consumers to characterize change and the role of natural and anthropogenic disturbance in coastal food webs over 13,000 years”
International Collaborator with PI Dr. Chris Harrod (University of Antofagasta)

2018 National Science Foundation: Advanced Biological Infrastructure [redacted])
“IsoBank: a centralized repository for isotopic data”
Lead PI with Co-PIs Drs. Jon Pauli (UWM), Chris Jordan (TACC), and Gabe Bowen (UU)

2018 National Science Foundation: Division of Integrative and Organismal Systems [redacted]5)
“The role of gut microbiota in supplying amino acids to their mammalian hosts”
Lead PI with Co-PIs Drs. Cristina Takacs-Vesbach (UNM) and Marilyn Fogel (UCR)

2018 National Science Foundation: Division of Environmental Biology [redacted]
“LTER: Sevilleta (SEV) Site: Climate variability at dryland ecotones”
Co-PI with Drs. Jennifer Rudgers (UNM), Marcy Litvak (UNM), Yiqi Luo (OSU), and Tom Miller (Rice)

2017 National Science Foundation: Division of Environmental Biology [redacted])
“EAGER: Collaborative Research: Environmental variability at dryland ecotones”
Co-PI with Drs. Jennifer Rudgers (UNM), Marcy Litvak (UNM), Yiqi Luo (OSU), and Tom Miller (Rice)

2016 National Science Foundation: Biological Oceanography [redacted])
“The energetic assembly of biological communities: a test with deep-sea woodfalls”
Co-PI with Dr. Craig McClain (LUMCON)

2016 National Science Foundation: Division of Environmental Biology [redacted]0)
“Moving beyond causation: the ecological consequences of the terminal Pleistocene extinction of North American megafauna.”
Co-PI with Drs. Felisa Smith (UNM) and Kate Lyons (Smithsonian)

2016 National Science Foundation, Archaeology [redacted]
“Late Pleistocene and early Holocene climate change and human ecology in the tropical Maya lowlands”
Senior Personnel with Co-PIs Drs. Keith Prufer, Yemane Asmerom, Doug Kennett, Brendan Culleton

2016 FONDECyT–Chile [redacted]
“Passerine birds facing marine environments: foraging on salty prey and fighting oxidative stress”
Senior Personnel with Co-PIs Drs. Pablo Sabat, Francisco Bozinovic, and Robert Nespolo

2015 North Pacific Research Board ($[redacted]
“The effects of sea ice loss on protein and fat stores of food-deprived polar bears”
Co-PI with Dr. Merav Ben-David (UW)

2014 National Science Foundation: Major Research Instrumentation ($[redacted]1)
“MRI: acquisition of instrumentation for compound-specific stable isotope analysis at UNM”
Lead PI with Co-PIs Drs. Zach Sharp, Blair Wolf, Dave Hanson, and Tom Turner (UNM)

2014 United States Fish & Wildlife Service–King Salmon, AK [redacted])
“Marine resource use and individual diet specialization of Alaska wolves”
Co-PI with Dom Watts (USFWS)

2013 Smithsonian Institution ($1[redacted])
“Biodiversity, Genomics, and Human Ecology of California's Channel Islands”
Collaborator with Drs. Torben Rick, Scott Sillett, Rob Fleischer, Jesus Maldonado, Kathy Ralls

2013 United States Fish & Wildlife Service–King Salmon, AK [redacted]
[redacted]Peninsula wolves”
Lead PI with Co-PI Dom Watts (USFWS)

2013 United States Geological Survey & National Park Service–Anchorage, AK ([redacted]
"Inter-tidal interactions among kelp and invertebrates in south central Alaska"
Lead PI

2012 North Pacific Research Board ([redacted])
"Retrospective study of walrus foraging and movement patterns during a major ecosystem shift in the Bering and Chukchi Seas"
Lead PI with Co-PIs Dr. Patrick R. Lemons (USFWS)

2012 National Park Service and U.S. Navy [redacted])
"Characterizing island fox dietary preferences across habitats on the Channel Islands"
Lead PI with Co-PI Drs. Katherine Ralls (Smithsonian) and Brian Cypher (CSUB)

2012 United States Geological Survey, Alaska Science Center–Anchorage, AK [redacted],000)
"Demographic parameters of walruses estimated from the analysis of stable isotopes in archived teeth"
Lead PI with Co-PI Dr. Dan Monson (USGS)

2012 United States Fish & Wildlife Service–Homer, AK ([redacted]
"Determining sea otter forage taxa in southeast Alaska through isotope markers in vibrissae"
Lead PI with Co-PI Dr. Verena Gill (USFWS)

2012 United States Fish & Wildlife Service–King Salmon, AK ([redacted]
"Marine resource use and individual diet specialization of Alaska Peninsula wolves"
Lead PI with Co-PI Dom Watts (USFWS)

2011 FONDECyT–Chile [redacted]
"The introduction of salmon in southern Chile and its effects on the trophic ecology of sea lions"
International Collaborator with PI Dr. Maritza Sepulveda Martinez (University of Valparaiso)

2011 United States Geological Survey, Alaska Science Center–Anchorage, AK ([redacted])
"Coastal ecosystem responses to influences from land and sea"
Co-Investigator with Co-PIs Drs. Jim Bodkin and Tim Tinker (USGS)

2011 National Science Foundation: Population and Community Ecology ([redacted]
"Extending the potential for hydrogen isotope tracers in ecology"
Lead PI with Co-PI Dr. Marilyn L. Fogel (Carnegie Institution of Washington)

2011 Montrose Settlements Restoration Program ($[redacted])
"Quantifying the diets of breeding bald eagles on the Channel Islands: a multi-proxy approach"
Lead PI with Co-PIs Drs. Paul W. Collins (SBNHM) and Peter Sharpe (IWS)

2011 Australian Marine Mammal Centre ([redacted]
"Southern right whales and stable isotopes: toward defining feeding habitat and trophic ecology"
Co-PI with PIs Mark Hindell, Simon Childerhouse, and Glenn Dunshea

2011 United States Geological Survey, Alaska Science Center–Anchorage, AK ([redacted])
"Demographic parameters of walruses estimated from the analysis of stable isotopes in archived teeth"
Lead PI with Co-PI Dr. Dan Monson (USGS)

2011 Fisheries and Oceans Canada-Ottawa, CAN ([redacted])
"Coupling isotopes and GPS-derived ringed seal movement data"
Lead PI with Co-PI Dr. Steve Ferguson (Fisheries & Oceans Canada)

2010 United States Fish & Wildlife Service–Homer, AK ([redacted]
"Determining sea otter forage taxa in southeast Ala[redacted]gh isotope markers in vibrissae"
Lead PI with Co-PI Dr. Verena Gill (USFWS)

2010 Montrose Settlements Restoration Program [redacted])
"Quantifying the diets of breeding bald eagles on the Channel Islands: a multi-proxy approach"
Lead PI with Co-PI Dr. Paul W. Collins (SBMNH)

2010 United States Geological Survey, Alaska Science Center–Anchorage, AK ([redacted])
"Coastal ecosystem responses to influences from land and sea
Lead PI with Co-PIs Drs. Jim Bodkin and Tim Tinker (USGS)

2008 National Science Foundation: Integrative Biology Program ($[redacted]
"Isotopes, niches, and birds: the functional ecology of an adaptive radiation"
Senior Personnel with PI Dr. Carlos Martinez del Rio (UW)

2007 Smithsonian Walcott Fund ([redacted])
"Stable isotope analysis of great gray owl (*Strix nebulosa*) invasions in North America"
Co-PI with Dr. Gary R. Graves (Smithsonian)

2007 Smithsonian Endowment Fund ([redacted])
"Evaluating dietary specialization in sea otters via fatty acid and stable isotope analysis"
Co-PI with Drs. Katherine Ralls & Olav Oftedal (Smithsonian)

2007 United States Fish & Wildlife Service-Anchorage, AK ([redacted])
“Investigating dietary links to valvular endocarditis in Lower Cook Inlet, AK sea otters”
Lead PI with Co-PIs Drs. Angela Doroff & Verena Gill (AKFWS)
2006 National Science Foundation: Biological Oceanography Program ([redacted]
“Holocene phylochronology and ecology of the northern fur seal”
Co-written with Drs. Liz Hadly & Marcel van Tuinen (Stanford University)

Peer-Reviewed Publications

*Student Author

Manuscripts in Review

Newsome, S.D., *Feeser, K., Bradley, C.J., *Wolf, C., Vesbach-Takacs, C., Fogel, M.L. (In Review) Quantifying the role of the gut microbiome in host essential amino acid metabolism. *ISME Journal*

Aurioles-Gamboa, D., Rosas Hernandez M., Hernandez Camacho, C., **Newsome, S.D.** (In Revision) Isotopic breadth and overlap in juvenile and adult female *Zalophus californianus*. *Marine Mammal Science.*

*Elliott Smith, E.A., Tinker, M.T., *Whistler, E.L., Kennett D.J., Vellanoweth, R.L., Gifford-Gonzalez, D., **Newsome, S.D.** (Submitted) The absent niche: range-wide historical ecology of the southern sea otter (*Enhydra lutris nereis*). *Conservation Biology.*

*Dyez, K.A., Koch, P.L., Ford, H.L., Schellenberg, S.A, **Newsome, S.D.**, Hylkema, M.G. (In Revision) Mollusk geochemical records show stable late Holocene climate on the central California coast. *The Holocene.*

*Fox, M.D., *Elliott Smith, E.A., Smith, J.E., **Newsome, S.D.** (In Revision) Amino acid $\delta^{13}C$ analysis reveals trophic plasticity in a common reef-building coral. *Functional Ecology.*

*Noble, J.D., Collins, S.L., *Hallmark, A.J., Wolf, B.O., **Newsome, S.D.** (In Review) Foraging strategies of individual silky pocket mice over a boom-bust population cycle in a highly stochastic arid ecosystem. *Oecologia.*

*Phillips, N.D., *Elliott Smith E.A., **Newsome, S.D.**, Houghton, J.D.R., Carson, C., Alfaro Shigueto, J., Mangel, J., Eagling, L.E., Harrod, C. (Submitted) Bulk tissue and amino acid stable isotope analysis reveal global ontogenetic patterns in ocean sunfish diet and habitat use. *Marine Ecology Progress Series.*

*Polo-Silva, C., Newsome, S.D., Kim, S.L., Soto-Jimenez, M.F., O’Hara, T.M., Galvan-Magana, F. (In Review) Ontogenetic variation in diet and habitat use of blue sharks (*Prionace glauca*) in the Mexican Pacific determined from stable isotope analysis. *Marine Ecology Progress Series*.

*Tome, C.P., *Elliott Smith, E.A., Lyons, S.K., Stafford, T.W., **Newsome, S.D.,** Smith, F.A. (In Review) The response of a small herbivorous mammal (*Sigmodon hispidus*, hispid cotton rat) to the late Pleistocene megafauna extinction. *Ecography.*

2019

Aurioles-Gamboa, D., **Newsome, S.D.**, Hassrick, J., Acosta-Pachon, T., Aurioles-Rodriguez, F., Costa, D.P. (2019) Vibrissa growth rates in free ranging northern elephant seal females (*Mirounga angustirostris*). *Marine Ecology Progress Series* 614: 199–207.

*Carter, W., Whiteman, J.P., Cooper-Mullin C., **Newsome, S.D.**, McWilliams, S. (2019) The dynamics of zebra finch flight muscle lipids revealed by fatty acid turnover. *Physiological and Biochemical Zoology.* 92: 239–251.

Maldonado, K., **Newsome, S.D.**, Razeto-Barry, P., Manuel Rios, J., Piriz, G., Sabat, P. (2019) Individual diet specialization is driven by phenotypic plasticity in digestive enzymes and trade-offs in animal performance. *Ecology Letters* 22: 128–137.

Sabat, P., Bozinovic, F., Contreras-Ramos, C., Nespolo, R., **Newsome, S.D.**, Quirici, V., Maldonado, K., Ramirez-Otarola, N., Sanchez-Hernandez, J.C. (In Press) The interplay between ambient temperature and salt intake affects oxidative status and immune responses in a ubiquitous Neotropical passerine, the rufous-collared sparrow. *Comparative Biochemistry and Physiology A.*

Tinker, M.T., Tomoleoni, J.A., Wietzman, B.P., Staedler, M., Jessup, D., Murray, M.J., Miller, M., Burgess, T., Bowen, L., Miles, A.K., Thometz, N., Tarjan, L., Golson, E., Batac, F., Dodd, E., Berberich, E., Kunz, J., Bentall, G., Fujii, J., Nicholson, T., **Newsome, S.D.**, Melli, A., LaRoche N., MacCormick H, Johnson, A., Henkel, L., Kreuder-Johnson, C., Conrad, P. (2019) Southern sea otter (Enhydra lutris nereis) population biology at Big Sur and Monterey, California — Investigating the consequences of resource abundance and anthropogenic stressors for sea otter recovery. *USGS Open-File Report 2019-1022*.

*Vokhshoori, N., McCarthy, M.D., Collins, P.W., Etnier, M.A., Rick, T.C., **Newsome, S.D.** (2019) Evaluating long-term shifts in the distribution and diet of North Pacific albatrosses with bulk tissue and amino acid isotope values. *Marine Ecology Progress Series* 610: 1–13.

Whiteman, J.P., *Elliott Smith E.A., *Besser, A.C., **Newsome, S.D.** (2019) A guide to using compound-specific stable isotope analysis to study molecules, organisms, and ecosystems. *Diversity* 11: 8.

Whiteman, J.P., Sharp, Z.D., Gerson, A.R., **Newsome, S.D.** (In Press) Relating Δ^{17}O values of animal body water to exogenous water inputs and metabolism. *BioScience.*

2018

Newsome, S.D., Chivers, S., Berman Kowalewski, M. (2018) The influence of lipid-extraction and long-term dimethyl sulfoxide preservation on carbon and nitrogen isotope values in cetacean skin. *Marine Mammal Science* 34:277–293.

*Elliott Smith, E.A., Harrod, C., **Newsome, S.D.** (2018) Untangling the importance of kelp carbon to an intertidal ecosystem using amino acid δ^{13}C analysis. *Ecosphere* 9: e02516.

*Gadek, C.R., **Newsome, S.D.**, Beckman, E.J., Chavez, E.N., Galen, S.C., Witt, C.C. (2018) Why are tropical mountain passes low for some species? Genetic and stable isotope tests for differentiation, migration, and expansion in elevational generalist songbirds. *Journal of Animal Ecology* 87:741–753.

Graves, G.R., **Newsome, S.D.**, Fogel, M.L. (2018) Stable hydrogen isotope variability in feather keratin of a migratory wood warbler. *PLoSONE* 13: e0193486.

*Hixon, S.W., *Elliott Smith E.A., Crowley B., Perry, G., Bankoff, R., Kennett, D., **Newsome, S.D.** (2018) Patterns in δ^{15}N values for amino acids in lemur bone are inconsistent with aridity driving megafaunal extinction in southwestern Madagascar. *Journal of Quaternary Science* 33: 958–968.

Hobson, K.A., Wassenaar, L.I., Bowen, G.J., Courtiol, A., Trueman, C.V., Voight, C.C., West, J.B., McMahon, K.W., **Newsome, S.D.** (2018) Outlook for using stable isotopes in animal migration studies. *Tracking Animal Migration with Stable Isotopes.* K.A. Hobson, L.I. Wassenaar, editors. Elsevier.

*Hughes, K., Whiteman, J.P., **Newsome, S.D.** (2018) The relationship between dietary protein content, body condition, and δ^{15}N discrimination in a mammalian omnivore. *Oecologia* 186: 357–367.

McMahon, K.W., **Newsome, S.D.** (2018) Compound-specific isotope analysis: the next frontier in isotopic tracking of animals. *Tracking Animal Movement with Stable Isotopes*. K.A. Hobson, L.I. Wassenaar, editors, Elsevier.

*Poblete, Y., Gutierrez, V., Venegas, C., Cid, V., **Newsome, S.D.**, Sabat, P., Vasquez, R. (2018) Behavioral and morphometric differences among populations: exploration and migration at different altitudes in Rufous collared sparrow. *Oecologia* 186: 931–938.

Resasco, J., Tuff, K., Cunningham, S.A., Melbourne, B.A., Hicks, A., **Newsome, S.D.**, Davies, K.F. (2018) Experimental forest fragmentation alters food-web structure and the environment: evidence from a generalist predator's niche shift. *Ecography* 41: 1209–1219.

*Rodriguez Curras, M.R., Fogel, M.L., **Newsome, S.D.** (2018) Assimilation and discrimination of hydrogen isotopes in a terrestrial mammal. *Oecologia* 188: 381–393.

*Rodriguez Perez, M.Y., Aurioles-Gamboa, D., Sanchez-Velasco, L., Lavin, M.F., **Newsome, S.D.** (2018) Isoscape of the upper Gulf of California: a tool for identifying critical habitat for the endemic and endangered vaquita (*Phocoena sinus*). *Marine Mammal Science* 34: 790–805.

*Tapia-Monsalve, R., **Newsome, S.D.**, Sanchez-Hernandez J.C., Bozinovic, F. Nespolo, R., Sabat P. (2018) Terrestrial birds in coastal environments: metabolic rate and oxidative status varies with the use of marine resources. *Oecologia* 188: 65–73.

Whiteman, J.P., Kim, S.L., McMahon, K.W., Koch, P.L., **Newsome, S.D.** (2018). Amino acid isotope discrimination factors for a carnivore: physiological insights from leopard sharks and their diet. *Oecologia* 188: 977–989.

2017

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Teaching & Advising Experience

Assistant/Associate Professor, University of New Mexico Department of Biology

Evolution & Ecology (Biology 303): Fall 2013, Spring 2015, Spring 2017, Spring 2018
Elemental Ecology (Biology 409/509): Spring 2014, Fall 2015, Fall 2017, Fall 2019
Biodiversity (Biology 191): Fall 2018
Ecology of the Past (Biology 409/509): Fall 2014, Fall 2016
Senior Honors Thesis Writing Seminar; Spring 2015–2018
Center for Stable Isotopes Brown Bag Seminar; 2014–2019 (every semester)
Applied Wildlife Ecology; Fall 2016

UNM Biology Department Committee Participation

Annual Review Committee: 2017–2018
Development of Ecology Concentration: 2013
Biology Scholarship Committee: 2013–2014
Undergraduate Honors Thesis Committee: 2013–2017

Organizer and Lecturer, Isotope Ecology Short Courses

Design and co-teach one- or two-week intensive short courses for graduate students and postdoctoral scientists on the uses of stable isotope analysis to study the ecology and physiology of marine and terrestrial plants and animals.

June 2013–2019: University of Utah (Salt Lake City, UT)
April 2017–2018: Sicily Center for International Education (Siracusa, Italy)
March 2012, July 2017, July 2019: Instituto Politecnico Nacional (La Paz, Mexico)
July 2017: Universidad de Guanajuato (Leon, Mexico)
March 2009: Universidad de La Plata (La Plata, Argentina)
May 2013: Centro Austral De Interdiciplinario Cientificas (Ushuaia, Argentina)
January 2012: Universidad de Los Lagos (Puerto Montt, Chile)
November 2012: Universidad de Chile (Santiago, Chile)

***Graduate Student Thesis Committee Member* (*Primary Advisor, †Graduated)**

*Emma Elliott Smith (PhD) – UNM Biology Department (Albuquerque, NM)
*†Deborah Boro (MS) – UNM Biology Department (Albuquerque, NM)
*†Laura Pages (MS) – UNM Biology Department (Albuquerque, NM)
*Alexi Besser (PhD) – UNM Biology Department (Albuquerque, NM)
†Meghan Balk (PhD) – UNM Biology Department (Albuquerque, NM)
†Matt Baumann (MS) – UNM Biology Department (Albuquerque, NM)
†Corrie Bergman (MS) – UNM Biology Department (Albuquerque, NM)
†Jennifer Noble (PhD) – UNM Biology Department (Albuquerque, NM)
†Melissa Pardi (PhD) – UNM Biology Department (Albuquerque, NM)
Catalina Tome (PhD) – UNM Biology Department (Albuquerque, NM)
†Alaina Pershall-Zimmerman (MS) – UNM Biology Department (Albuquerque, NM)
†Cyler Conrad (PhD) – UNM Anthropology Department (Albuquerque, NM)
†Marian Hamilton – UNM Anthropology Department (Albuquerque, NM)
Clayton Meredith – UNM Anthropology Department (Albuquerque, NM)
Jon Dombrosky – UNM Anthropology Department (Albuquerque, NM)
†Carl Cloyed – University of Louisville (Louisville, KY)
†Carlos Polo – Universidad Nacional Autonoma de Mexico (Mexico City, Mexico)
†Geraldine Busquets – Instituto Politecnico Nacional (La Paz, Mexico)
Carlos Alberto – Instituto Politecnico Nacional (La Paz, Mexico)
Yamila Becker – Centro Austral De Interdiciplinario Cientificas (Ushuaia, Argentin[redacted])

B.S. Senior Honors Thesis Students

Sarah Foster; Spring 2015; B.S. Biology; *Magna Cum Laude.*
Allyson Richins; Spring 2015; B.S. Biology; *Summa Cum Laude*
Mauriel Curras Rodriguez; Spring 2016; B.S. Biology; *Summa Cum Laude*
Chauncey Gadek; Spring 2016; B.S. Biology; *Summa Cum Laude*
Shannon O'Brien; 2017; B.S. Psychology (Honors College); *Summa Cum Laude*

Tommy Galfano; 2019 (Expected); B.S. Biology
Vishwa Patel; 2020 (Expected); B.S. Environmental Sciences
Alana Robinson; 2021 (Expected); B.S. Biology

***Teaching Assistant* (UC-Santa Cruz, 2000–2005)**

Served as teaching assistant and lab coordinator for five undergraduate courses in the Earth Sciences Department, including *The Natural History of Dinosaurs (2x), Vertebrate Paleontology, The Fossil Record,* and *The Earth as a Chemical System*.

***Field Course Teaching Assistant* (Dartmouth College, 1997–1999)**

Served as teaching assistant and logistical coordinator for six field-based undergraduate courses focusing on stratigraphy, paleontology, tectonics, structural geology, mineralogy, hydrology, and geochemistry. These intensive 3-week field programs were staged in the Bighorn Basin of Wyoming (1997/98/99), Yellowstone National Park (1997/98), and Costa Rica (1999).

Shawn P. Johnson, D.V.M., M.P.V.M.

Licensed in: CA 12619, AK 511 DEA Registration: BJ8945555

[redacted]
johnsons@tmmc.org

EDUCATION

Don Low Practitioner Fellowship in Anesthesia, 2012
University of California - Davis, School of Veterinary Medicine

Master of Preventive Veterinary Medicine, December 2002
University of California - Davis, School of Veterinary Medicine
Advisors: Linda Lowenstein, Ian Gardner
Thesis: Aerobic bacterial flora of the vagina and prepuce in California sea lions and investigation of associations with urogenital carcinomas

Doctor of Veterinary Medicine, 1996
Iowa State University, College of Veterinary Medicine

AquaVet I & II, 1993, 1996
Marine Biological Laboratory, Woods Hole, MA.

Exchange Abroad Program
Flinders University, Adelaide, South Australia, 1992

Incomplete B. A., Aquatic Biology, Pre-Vet emphasis, 1989-92
University of California, Santa Barbara

PROFESSIONAL EXPERIENCE

The Marine Mammal Center
Director of Veterinary Science, 2010 – present
Supervisor: Jeff Boehm

- Manage all aspects of animal care and research for an average of 600 stranded marine mammals yearly.
- Supervise 17 staff in the veterinary, stranding, and research departments
- Member IACUC for TMMC research
- Hawaiian monk seal rehabilitation at hospital in Kona, Hawaii.

U. S. Navy Marine Mammal Program, National Marine Mammal Foundation
Clinical Veterinarian, June 2006 – 2010
Supervisors: Eric Jenson (Navy), Cynthia Smith (Foundation)

- Sea lion and dolphin preventive medicine program, clinical care, and surgery
  - -Attending veterinarian for a population of over 25 sea lions and 75 dolphins
  - -Deployment worldwide to provide veterinary support for Navy animals
- Research:
  - -Managed study of renal disease in bottlenose dolphins
  - -Performed renal scintrigraphy and CT exams to evaluate renal function
  - -Managed stem cell and regenerative medicine study in bottlenose dolphins
  - -Developed adipose stem cell collection technique
- Development of Techniques:

-Phlebotomy therapy for iron overload in bottlenose dolphins
-Advanced endodontic techniques for sea lion dental disease
-Transhepatic catheterization in bottlenose dolphins
-Arterial catheterization for anesthesia monitoring in sea lions

Marine Mammal Veterinary Consultant

National Marine Mammal Laboratory, Alaska Science Center, August 2004 – present
Supervisor: Peter Boveng,

- Polar Ecosystem Program contract veterinarian/capture team member
- MMPA permitted research projects
- Provided veterinary support and training while living on boat and field camps in close quarters with scientists and crew.
  -Harbor seal captures and sedation in Cook Inlet, AK
  -Bearded seal capture and sedation in Kotzebue Sound, AK

Alaska SeaLife Center, 2005 – present
Supervisor: Jo-Anne Mellish

- Veterinary anesthesia and surgical support for juvenile Steller sea lion Life History Transmitter project performed un MMPA permits and IACUC approval. Worked on ship for up to 14 days in Prince Williams Sounds with research team.

Alaska Department of Fish and Game, November 2003 – 2009
Supervisors: Tom Galett, Lorrie Rea

- Captured and anesthetized over 100 sea lions for biological sampling and research
  -Steller sea lions: juvenile captures and pup branding in AK and Russia
  -Harbor seals: anesthesia and surgical transmitter implants in Glacier Bay, AK

The Marine Mammal Center, Hawaiian Monk Seal Second Chance Program, January 2004
Supervisors: Frances Gulland, Bob Braun

- Seal rehab team leader on Tern Island, French Frigate Shoals

Wildlife Health Center, School of Veterinary Medicine, University of California - Davis
Wildlife Veterinarian, March 2005 – January 2006
Supervisor: Michael Ziccardi

- NOAA/National Marine Fisheries Service Contract:
  -Development of National Guidelines for response to oiled marine mammals
  -Taught two-day oil spill response trainings to NOAA regional marine mammal stranding networks

Alaska SeaLife Center, December 2003 - December 2004
Associate Veterinarian and Rehabilitation Manager
Supervisor: Pam Tuomi

- Responsible for captive care and research assistance for marine mammals, fish, and birds
- Managed rehabilitation department, staff, interns, and local stranding network volunteers
- Steller sea lions: veterinary support and anesthesia for Transient Juvenile Sea Lion Project
- Grant funded research project: Evaluation of Hemoglobinometer in Aquatic Birds

Oiled Wildlife Care Network, Wildlife Health Center, University of California-Davis
Oil Spill Response Veterinarian, December 2002 - August 2003
Supervisor: Michael Ziccardi

- Clinical Veterinarian at San Francisco Bay Area Oil Spill Care Clinic
  -Managed clinical care for seabirds in rehabilitation and related research projects
  -Trained rehabilitation staff and volunteers in avian medicine and oil spill response
- Provided clinical veterinary services and emergency care to seabirds and marine mammals

exposed to petroleum products in California

- Revised and update current protocols for the care of oiled marine mammals and seabirds
- Assisted teaching volunteers, rehabilitators, and students during oil spill response trainings
- Research and projects:
  - Treatment of anemia in oiled seabirds
  - Use of hemoglobin to diagnose anemia in avian species

The Marine Mammal Center

Adjunct Veterinarian, 2000 - 2002
Supervisor: Frances Gulland

- Performed clinical duties and necropsies on as needed basis
- Mentored and trained veterinary students
- Research projects:
  - Amoxicillin pharmacokinetics in harbor seals and northern elephant seals
  - Antimicrobial susceptibility of bacteria isolated from stranded pinnipeds
  - *Arcanobacterium phocae*: prevalence and clinical manifestations
  - Vaginal and preputial bacterial flora of California sea lions

International Bird Rescue

Oil Spill Response and Rehabilitation Veterinarian, October 1999 - February 2000
Supervisor: Jay Holcomb

- Provided medical care for oiled wildlife during oil spill response
- Lead veterinary care techniques for seabirds and marine mammals in oil spill response trainings
- Developed clinical research in an effort to improve survival of oiled wildlife

Johnson Veterinary Service: Veterinary Relief and Emergency

Part-time and independent contractor in Alaska and California, April 1997 - Present

- Small and exotic animal medicine and surgery
- Some of my veterinary employers:
  - Fairfax Veterinary Clinic, Dave Mohler, DVM
  - Mill Valley Pet Clinic, Charles Comella, VMD
  - Ross Valley Veterinary Clinic, Grace Bransford, DVM
  - Acorn Veterinary Clinic, Sally Borges, DVM
  - Sacramento SPCA, Giselle Chan, DVM

VetSmart Pet Hospitals and Health Centers

Practice Partner and Hospital Director, June 1996 - April 1997

- Small animal medicine and surgery
- Practice management and development: inventory, employee, client, marketing

PROFESSIONAL AFFILIATIONS

American Veterinary Medical Association
International Association for Aquatic Animal Medicine
American Association of Zoo Veterinarians
Society of Marine Mammalogy
Omega Tau Sigma, Professional Veterinary Fraternity

PUBLICATIONS

Fahlman A, Loring SH, **Johnson SP**, Haulena M, Trites AW, Fravel VA and 770 Van Bonn WG (2014) Inflation and deflation pressure-volume loops in anesthetized 771 pinnipeds confirms compliant chest and lungs. Front. Physiol. **5**:433. doi: 10.3389/ 772 fphys.2014.00433

Sterling JT, Springer AM, Iverson SJ, **Johnson SP**, Pelland NA, Johnson DS, Lea M, Bond NA (2014) The Sun, Moon, Wind, and Biological Imperative-Shaping Contrasting Wintertime Migration and Foraging Strategies of Adult Male and Female Northern Fur Seals (Callorhinus ursinus). PloS ONE 9:e93068

Cassle SE, Jensen ED, Smith CR, Meegan JM, **Johnson SP**, Lutmerding B, Ridgway S, Francis-Floyd R (2013) Diagnosis and successful treatment of a lung abscess associated with Brucella species infection in a bottlenose dolphin (*tursiops truncatus*). Journal of Zoo and Wildlife Medicine 44:495-99.

Smith CR, Venn-Watson S, Wells RS, **Johnson SP**, Maffeo N, Balmer BC, Jensen ED, Townsend FI and Sakhaee K (2013) Comparison of nephrolithiasis prevalence in two bottlenose dolphin (*Tursiops truncatus*) populations. Frontiers in Endocrinology 4:145.

Smith CR, Solano M, Lutmerding BA, **Johnson SP**, Meegan JM, Le-Bert CR, Emory-Gomez F, Cassle S, Carlin K, Jensen ED (2012) Pulmonary ultrasound findings in a bottlenose dolphin *Tursiops truncatus* population. Diseases of Aquatic Organisms 101: 243-55.

Johnson SP, Catania JM, Harman RJ, Jensen ED (2012) Adipose-derived stem cell collection and characterization in bottlenose dolphins (*Tursiops truncatus*). Stem Cells and Development 21: 2949-2957.

Mazzaro LM, Johnson SP, Fair PA, Bossart G, Carlin KP, Jensen ED, Smith CR, Andrews GA, Chavey PS, Venn-Watson S (2012) Iron indices in bottlenose dolphins (*Tursiops truncates*). Comparative Medicine 62:508-15.

Houser DS, Moore PW, **Johnson S**, Lutmerding B, Branstetter B, Ridgway SH, Trickey J, Finneran JJ, Jensen, Hoh C (2010) Relationship of blood flow and metabolism to acoustic processing centers of the dolphin brain. Journal of the Acoustical Society of America 128: 1460-1466.

Venn-Watson S, Smith CR, **Johnson SP**, Daniels R, Townsend F (2010) Clinical relevance of urate nephrolithiasis in bottlenose dolphins (*Tursiops truncatus*) Diseases of Aquatic Organisms 89:167-177.

Johnson SP, Venn-Watson S, Cassle SE, Smith CR, Jensen ED, Ridgway SH (2009) Use of phlebotomy treatment in bottlenose dolphins with iron overload. Journal of the American Veterinary Medical Association 235:194-200.

Johnson S, Ziccardi M (2006) Marine Mammal Oil Spill Response Guidelines. NOAA Technical Memorandum

Johnson SP, Lowenstine L, Gulland FMD, Jang S, Imai D, Almy F, Delong R, Gardner I (2006) Aerobic bacterial flora of the vagina and prepuce in California sea lions (*Zalophus californianus*) and investigation of associations with urogenital carcinomas. Veterinary Microbiology 114: 94-103.

Johnson SP, Jang S, Gulland FMD, Miller MA, Casper DR, Lawrence J, Herrera J (2002) Characterization and clinical manifestations of *Arcanobacterium phocae* infections in Marine mammals stranded along the central California coast. Journal of Wildlife Diseases. 38(1): 136-144.

Gulland FM, Stoskopf MK, **Johnson SP**, Riviere J, Papich MG (2000) Amoxicillin pharmacokinetics in harbor seals (Phoca vitulina) and northern elephant seals (*Mirounga angustirostris*) following single dose intravenous administration: Implications for interspecific dose scaling. Journal of Veterinary Pharmacology and Therapeutics 23 (4): 223-228.

Goldstein T, **Johnson SP**, Phillips AV, Hanni KD, Fauquier DA, Gulland FM (1999) Human-related injuries observed in live stranded pinnipeds along the central California coast 1986-1998. Aquatic Mammals. 25(1): 43-51.

Johnson SP, Nolan S, Gulland FM (1998) Antimicrobial susceptibility of bacteria isolated from pinnipeds stranded in central and northern California. Journal of Zoo and Wildlife Medicine. 29(3): 288-294.

Goldstein T, **Johnson SP**, Werner LJ, Nolan S, Hilliard BA (1998) Causes of erroneous white blood cell counts and differentials in clinically healthy young Northern elephant seals (*Mirounga angustirostris*). Journal of Zoo and Wildlife Medicine. 29(4): 408-412.

CLAIRE SIMEONE

[redacted]
simeonec@tmmc.org

CURRENT POSITION

NOAA-NMFS/The Marine Mammal Center — **Sausalito, CA**
Conservation Medicine Officer — **2013-Present**

Main projects include Unusual Mortality Event response, international capacity-building, field work veterinary support, and development of the Marine Mammal Health Map. Program Coordinator of International Veterinary In-Residence training program at TMMC.

EDUCATION

National Marine Mammal Foundation/SeaWorld San Diego — **San Diego, CA**
Specialty Intern — **2012-2013**

Veterinary Specialty Hospital — **San Diego, CA**
Small Animal Rotating Intern — **2011-2012**

Virginia-Maryland Regional College of Veterinary Medicine — **Blacksburg, VA**
Doctor of Veterinary Medicine — **May, 2011**

University of Maryland — **College Park, MD**
B.Sc. - Physiology and Neurobiology — **May, 2007**

LICENSES/CERTIFICATES

California Veterinary Medical Board — **Sacramento, CA**
License Number: 18691 — **June, 2011**

USDA-APHIS Category II Veterinary Accreditation — **Sacramento, CA**
National Accreditation Number: 059027 — **June 2011**

Oiled Wildlife Care Network – Oil Spill Response — **Sausalito, CA**
24 Hour HAZWOPER — **April, 2014**

CLINICAL EXPERIENCE

2013 – present **TMMC – Sausalito, CA and Kona, HI**
Clinical veterinary care of pinnipeds. Responsibilities include primary care of California sea lions, northern elephant seals, harbor seals, fur seals, and endangered Hawaiian monk seals; necropsy of pinnipeds and cetaceans.

2013 – present **TMMC – International Veterinary In-Residence training program**
Program coordinator. Participants spend three months training at TMMC main hospital in Sausalito, CA in marine mammal medicine, anesthesia, surgery, necropsy, and rescue/release. Responsibilities included participant selection, mentorship in clinical responsibilities and development of research project.

2014, 2015 **NOAA/TMMC/NMML – Aleutian Islands, AK**
Harbor seal population monitoring. Responsibilities included injectable sedation and anesthetic monitoring of phocids, biopsy, sample collection.

2014 **TMMC/NMML – San Miguel Island, CA**
California sea lion and northern fur seal population health assessment. Responsibilities included inhalant anesthesia and monitoring of otariids, sample collection.

2014 **NOAA/TMMC – Barataria Bay, LA**
Natural Resource Damage Assessments – dolphin health assessments. Responsibilities included monitoring, biopsy, sample collection.

2013 **NOAA/TMMC – Virginia Beach, VA; Myrtle Beach, SC**
Cetacean field response and necropsy.

2013-2014 **NOAA/TMMC – Molokai; Kauai, HI**
Endangered Hawaiian monk seal CritterCam placement. Responsibilities included injectable sedation, monitoring, venipuncture, and sample collection.

2013 **NOAA/NMML – Aleutian Islands, AK**
Pup anesthesia for branding and sample collection work at multiple sites along Aleutian Island chain. Responsibilities included inhalant anesthesia, monitoring, and sample collection.

2013-2014 **NOAA/Monterey Bay Aquarium – Gaviota, CA**
Sea otter transmitter placement and retrieval. Responsibilities included injectable immobilization, laparatomy, monitoring, venipuncture, and sample collection.

2012-2013 **National Marine Mammal Foundation – San Diego, CA**
Clinical internship – marine mammal medicine. Veterinary care of captive California sea lions and bottlenose dolphins. Advanced diagnostics including endoscopy, ultrasound, anesthesia, MRI.

2012-2013 **SeaWorld – San Diego, CA**
Clinical internship – marine animal medicine. Veterinary care of captive mammal, avian, reptile, and fish species. Rehabilitation of marine mammal and avian species.

MANUSCRIPTS

Johnson SP, **Simeone CA**. Disease. In: Castellini M, Mellish J (eds.). *Marine Mammal Physiology: Requisites for Ocean Living*. CRC Press. *In final review for publication.*

Simeone C, Gulland F, Norris T, Rowles T. 2015. A systematic review of changes in marine mammal health in North American since passage of the Marine Mammal Protection Act of 1972. In final review at *PLoS One*.

Gutierrez J, **Simeone C**, Gulland F, Johnson S. 2014. Development of a retrobulbar and auriculopalpebral nerve block in California sea lions (*Zalophus californianus*). Accepted for publication in *Journal of Zoo and Wildlife Medicine*.

Nuckton T, **Simeone C**, Jones R. 2014. California sea lion (*Zalophus californianus*) and harbor seal (*Phoca vitulina*) bites and contact abrasions in open-water swimmers: A series of 11 cases. Accepted for publication in *Wilderness and Environmental Medicine*.

Esson DW, Nollens HH, Schmitt TR, **Simeone CA**, Stewart B. 2015. Aphakic phacoemulsification and automated anterior vitrectomy and post-return monitoring of a rehabilitated harbor seal (Phoca vitulina richardsi) pup. *Journal of Zoo and Wildlife Medicine* 46(3):647-651.

Phan TG, Gulland F, **Simeone C**, Deng X, Delwart E. 2014. Sesavirus: prototype of a new parvovirus genus in feces of a sea lion. *Virus Genes* Epub Oct 2, 2014.

Simeone CA, Papich M, Nollens H, Meegan JM, Schmitt T, Jensen ED, Smith, CR. 2014. Pharmacokinetics of single-dose oral meloxicam in bottlenose dolphins (*Tursiops truncatus*). *Journal of Zoo and Wildlife Medicine* 45(3): 594-599.

Simeone CA, St. Leger J, Nollens H, Schmitt T. Characterization of a follicular cell carcinoma of the thyroid in a yellowbar angelfish (*Pomacanthus maculosus*). *Journal of Zoo and Wildlife Medicine* 46(2): 431-434.

Gomez M, Mieres M, Moroni M, Mora A, Barrios N, **Simeone C**, Lindsay D. 2010. Meningomyelitis due to nematode infection (*Gurltia paralysans*) in four cats. *Veterinary Parasitology* 170: 327-330.

SELECTED PRESENTATIONS

Simeone C. I am Dr. Claire Simeone of The Marine Mammal Center and I am working on the sea lion crisis our coast is facing. Invited participant, Reddit Ask Me Anything for World Ocean's Day.
Simeone C. Conserving San Francisco Bay: What Marine Mammal Health Can Teach Us About the Health of the Bay. Bay Science Collaborative, Romberg Tiburon Science Center, 2015. Oral presentation.

Barbieri M, Wickham D, Boehm J, Gulland F, Johnson S, Littnan C, Norris T, Rowles T, and **Simeone C.** Advancing Hawaiian monk seal conservation through collaborative approaches to malnourished animal transport, care and rehabilitation. Hawaii Conservation Conference, 2014. Oral presentation.

Simeone CA. Sick seals and seizing sea lions: what marine mammals can tell us about the health of our oceans. Marin Science Seminar, 2014. Oral presentation.

Simeone CA. Mapping marine mammal health: what marine mammals can tell us about the health of our oceans. Science Sunday at Seymour Center at Long Marine Laboratory, 2014. Oral presentation.

Simeone CA, Norris T, Palmer LJ, St. Leger J, Danil K, Chivers S, Berman M, Gulland FMD. 2014. Marine mammal health map: Goals, vision, and results from pilot study using data from California stranding responders. Proceedings from the International Association of Aquatic Animal Medicine Annual Conference. Oral presentation.

Simeone CA, Levine G, Barbieri M. Conservation medicine in endangered Hawaiian monk seals. Proceedings from the International Association of Aquatic Animal Medicine, 2014. Oral presentation.

Simeone CA, Gulland FMD, Norris T, Palmer L, St. Leger J, Danil K. 2014. Data integration of marine mammal health map. California Stranding Network Annual Meeting. Oral presentation.

Simeone CA, Nollens H, Meegan JM, Schmitt T, Jensen ED, Papich M, Smith, CR. 2013. Pharmacokinetics of single-dose oral meloxicam in bottlenose dolphins (*Tursiops truncatus*). International Association of Aquatic Animal Medicine Annual Conference. Oral presentation.

Simeone CA, St. Leger J, Nollens H, Schmitt T. 2013. Thyroid carcinoma in a Yellowbar angelfish (*Pomacanthus maculosus*). International Association of Aquatic Animal Medicine Annual Conference. Poster presentation.

WORKSHOPS/COMMITTEES

International Stranding Response Working Group. International Whaling Commission. 2015 – present. Convenor.

Cetacean Emerging and Resurging Diseases Working Group. International Whaling Commission. 2014 – present. Steering committee.

International marine mammal stranding toolkit workshop. Woods Hole Oceanographic Institution, 2014. Workshop planning committee.

Marine mammal health map: Scoping workshop for western states. Sausalito, California, 2014. Workshop planning committee.

Advances in care for rehabilitating marine mammals. Workshop, California Stranding Network Annual Meeting, 2014. Workshop chair.

JOURNAL REVIEWER

Polar Biology
Aquatic Mammals
North Pacific Research Board
Journal of Wildlife Diseases

PROFESSIONAL MEMBERSHIPS

International Association of Aquatic Animal Medicine
International Whaling Commission
American Cetacean Society
Wildlife Disease Association
Society for Marine Mammalogy

TERRIE M. WILLIAMS
Wildlife Eco-physiologist
Distinguished Professor of Ecology and Evolutionary Biology
Center for Ocean Health – Long Marine Laboratory
130 Shaffer Road, University of California-Santa Cruz, CA 95060
(831) 459-5123, williams@biology.ucsc.edu

EDUCATION

1988-89	University of California, San Diego: Certificate Program in Molecular Biotechnology.
1981-84	Scripps Inst. Oceanography – UCSD, San Diego, CA, Post-doctoral study (Physiology-G. Kooyman- mentor)
1981	Rutgers University, New Brunswick, NJ, Ph.D. (Environmental and Exercise Physiology, T.M. Casey-mentor)
1979	Rutgers University, New Brunswick, NJ, M.S. (Physiology)
1976	Douglass College, New Brunswick, NJ, B.A. (Biology, Graphic Arts)

EMPLOYMENT

2001-present	Professor of Ecology and Evolutionary Biology, University of California, Santa Cruz Antarctic Field Program- Hunting Behavior and Navigation Physiology of Weddell Seals Arctic Field Program – Physiology of Narwhals, Energetics of Polar Bears Marine Field/Lab Program- Cardiovascular Physiology and Energetics of Endangered Pinnipeds and Cetaceans; Carnivore Field/Lab Program- Foraging Behavior and Energetics of African lions, mountain lions and Alaskan wolves
1997-01	Associate Professor of Biology, University of California, Santa Cruz Antarctic Field Program- Hunting Behavior and Physiology of Weddell Seals African Field Program: -Thermoregulation and Water Use by African Elephants Bahamas Field Program- Biomechanics and Thermal Biology of Diving Dolphins
1994-97	Assistant Professor of Biology, University of California, Santa Cruz
1993-94	Scientific Officer, Molecular, Cellular, and Environmental Biological Processes, Office of Naval Research, 800 N. Quincy, Arlington, VA
1993-94	Marine Research Physiologist, University of California, Santa Cruz, CA; Program Manager: Physiology of Diving in Marine Vertebrates. Collaborative program with NRaD (San Diego).
1990-93	Research Physiologist, NOSC Hawaii Laboratories, Kailua, HI; Program Manager: Thermal and Exercise Physiology of Cetaceans
1991-	Alaska Field Research, Ecological Energetics and Indices of Body Condition in Steller Sea Lions; Supported by National Marine Fisheries Service
1989-95	Research Physiologist, Exxon Valdez Oil Spill; Toxicological evaluation and field tests for assessing the effects of petroleum hydrocarbons on oiled wildlife.
1987-88	Africa Field Research, Isolating the origin of FIP virus in captive and wild cheetahs of South West Africa; Locomotor morphology, physiology and biochemistry of the African cheetah.
1987	Arctic Expedition, Hematological and Physiological Indices of Diving Capacity of Narwhals. (Joint Program with Canadian Fisheries Service).
1986-89	Research Associate, Sea World Research Institute, San Diego, CA; Program Manager: Swimming mechanics and energetics of marine animals. Skeletal muscle physiology in diving birds and mammals. Thermoregulation in sea otters (*Enhydra lutris*).
1985-87	Research Associate, San Diego Zoo Research Department, San Diego, CA. Research Projects: Skeleton maintenance in wild and captive cheetahs. Locomotor mechanics and

	energetics in birds and mammals. Thermoregulation in elephants.
1986	Alaska Expedition, Sea otter swimming speed and behavior during acoustic and olfactory stimuli; Supported by Minerals Management Service, Department of the Interior.
1983-84	NIH Individual Postdoctoral Research Trainee, Physiological Research Laboratory, Scripps Institution of Oceanography, La Jolla, CA. Research Projects: Cardiovascular and tissue oxygen adjustments during swimming in marine mammals.
1983-84	Antarctic Expedition, Benthic ecology of McMurdo Sound. (P.I. - Paul Dayton, Gerald Kooyman).
1981-83	NIH Postdoctoral Fellow, Physiological Research Laboratory, Scripps Institution of Oceanography, La Jolla, CA. Research Projects: Hydrodynamics and energetics of swimming in marine mammals; physiological effects of submerged swimming including cardiovascular and respiratory responses.
1983	Australia Expedition, Habitat variability of mammals and birds of Eastern Australia.

PROFESSIONAL ACTIVITIES, HONORS, AWARDS & GRANTS

MEMBERSHIP IN SOCIETIES

American Physiological Society
Society for Marine Mammalogy
Society for Integrative and Comparative Physiology
American Zoological Association
Research Fellow, Zoological Society of San Diego
Fellow, California Academy of Sciences
Explorer Fellow, Wings WorldQuest

PROFESSIONAL ACTIVITIES

2018- present	Board of Reviewers, Comparative Physiology for Science Magazine
2013- 2018	Associate Editor Proceedings of the Royal Society B: Biological Sciences
2006-2008	Associate Editor, Marine Mammal Science
2000-2006	Advisory Panel, NOAA-NMFS Steller Sea Lion Recovery Team
1996-1998	Secretary, Society for Marine Mammalogy
1989- present	Annual Workshop Organizer and Presenter, Mitigating the effects of oil on marine mammals
1981- present	Reviewer National Science Foundation, National Geographic, Science, Nature, PNAS, Journal of Experimental Biology, Polar Biology, Marine Mammal Science

GRANTS (recent)

2017- 2021	Office of Naval Research, Physiological Consequences of Flight Responses in Diving Mammals: Critical metrics for assessing the impacts of novel environmental stimuli on cetaceans and other marine living species
2018-2020	Howard Hughes Medical Institute, Thermal Safari: Undergraduate STEM program
2017-2019	Office of Naval Research, Marine Mammal Diving Physiology Workshop
2017-2019	Sea World-Bush Gardens – lion Energetics
2014-2018	NSF Polar Programs, Geomagnetic Navigation by Weddell Seals beneath the Antarctic Ice, (collaborative grant with R. Davis- Texas A&M University and L. Fuiman – University of Texas)
2013-2017	NSF DBIR, Energy Scavenging Collar for Animal Physiology and Ecology (ESCAPE), (collaboration with C. Wilmers – Environmental Studies and G. Elkaim, Computer

	Engineering)
2013-2016	Office of Naval Research, High Risk Behaviors in Marine Mammals: Linking behavioral responses to anthropogenic disturbance to biological consequences
2010-2014	NSF DBI, ANIMA (Accelerometer Network Integrator for Mobile Animals) (collaborative grant with C. Wilmers – Environmental Studies and G. Elkaim, Computer Engineering
2008-2012	NSF Polar Programs, Collaborative Research: Hunting in Darkness: Behavioral and Energetic Strategies of Weddell Seals in Winter (collaborative grant with R. Davis-Texas A&M University and L. Fuiman – University of Texas)
2006-2009	US Department of Education, Conservation Biology through GAANN: Practical Skills for Applied Coastal Ecology. Continuation of 2001-2004 grant.
2006-2008	National Center for Ecological Analysis and Synthesis, Conservation Planning for Ecosystem Functioning: Testing predictions of ecological effectiveness for marine predators (with D. Doak)
2005-2008	Office of Naval Research, Physiological and Biochemical Neuroprotection in Cetaceans: Are some marine mammal species safeguarded from emboli formation and barotrauma?

HONORS AND AWARDS

2019	August Krogh Distinguished Lectureship, American Physiological Society, Comparative and Evolutionary Section
2016	Rutgers-Cook College, Dennis M. Fenton Distinguished Graduate Alumni Award
2015	Distinguished Author, 2015 Campus Reads, Notre Dame High School, San Jose, CA
2014	Distinguished Visiting Scientist and Author, Boise State University, Boise, ID
2013	Distinguished Visiting Scientist, University of New South Wales, Sydney, Australia
2013	AAAS/Subaru Science Book and Film Prize (Winner- Young Adult Science Books) and
2011	Medal Finisher, Ironman Triathlon 140.6 Mile Competition, Coeur d'Alene, ID
2009	The Laurence Irving- Per Scholander Memorial Lecturer in Comparative Physiology
2007	Wings WorldQuest, Ocean Explorer Award
	Fellow Induction in the California Academy of Sciences
2006	USGS Antarctic Site Designation, Terrie Bluff, Antarctica honoring Weddell fieldwork
2004- 2006	International Union of Physiological Sciences, Chair in Diving Physiology
2004	Douglass College, Distinguished Achievement Alumni Award
2002	Discover Magazine 50 Most Important Women in Science
	UCSC Biological Sciences Instructor of the Year Award
2000-2003	Ida Benson Lynn Endowed Chair in Ocean Health, UCSC
1987-present	Fellow of the Zoological Society of San Diego
1983-84	NIH Individual National Research Service Award

PUBLICATIONS

In Review

Pagano, A.M, Cutting, A., Nicassio-Hiskey, N., Hask, A., and Williams, T.M. (2018) Energetic costs of aquatic locomotion in a subadult polar bear (for **Marine Mammal Science**).

Suraci, J, Frank, L., Oriol-Cotterill, A., Ekwanga, S, Williams, T., Wilmers, C. 2018. Behavior-specific habitat selection by African lions promotes coexistence with humans (for **Ecology**).

<u>Papers Published</u>

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Abstracts (note co-authored presentations by colleagues, post-doctoral researchers and graduate students generally not included in list)

Williams, T.M. and Heide-Jørgensen, M.P. 2017. Cetacean Escapes: Assessing the physiological cost of fear in deep-diving whales. Society for Marine Mammalogy, Oct. 23-27, Halifax, Canada.

Williams, T.M. 2017. The great escape: How large, carnivorous mammals move out of harm's way. Plenary Speaker, International Mammalogical Congress, Perth, Australia, July, 2017.

Williams. T.M. 2016. The Biology of Big: Discovering the extraordinary costs of survival at the top of the food chain. Plenary Speaker, Society for Integrative and Comparative Biology, Jan. 3-7, Portland, OR.

Williams, T.M., Richter, B., Kendall, T., Ribeiro-French, C., John, J., Thometz, N. 2015. Degrees of Physiological Freedom: A new analytical tool for determining 3-dimensional critical habitats for marine mammals. Society for Marine Mammalogy, Dec. 12-18, San Francisco, CA.

Williams, T.M. 2015. The Moveable Feast: A comparison of foraging tactics and energetics in large, stealthy marine and terrestrial carnivores. Society for Integrative and Comparative Biology, Jan. 3-7, West Palm Beach, FL.

Bryce C.M., and Williams T.M. 2015 Locomotive costs of domestic canids: exploring breed specific energetic economy. Society for Integrative and Comparative Biology, Jan. 3-7, West Palm Beach, FL.

Williams, T.M., Wilmers, C., and Wolfe, L.L. 2013. Not-So-King-of-The-Mountain lions: high energetic costs of puma moving over uneven terrains. Invited speaker for the Symposium on Energetic Costs and Behavioral Patterns in Mammals. International Mammalogical Congress, Belfast, Ireland, August 2013.

Williams, T.M. 2013. Racing to extinction: the high physiological cost of flight responses in large mammalian predators. Invited speaker for the Symposium on Physiological Approaches to Conservation. International Mammalogical Congress, Belfast, Ireland, August 2013.

Williams, T.M. and Lindberg, D. 2013. Gut Instinct: Digestive capacity and the evolution of marine mammals. The Society for Integrative and Comparative Biology, San Francisco, CA, January 4 - 8.

Williams, T.M. 2012. The Energetic and Biomechanics of Mountain Lions. The Society for Integrative and Comparative Biology Charleston, SC, January 3 - 6.

Williams, T.M., Kendall, T., Richter, B., Berry, P., Noren, S., Fuiman, L., Farrell, E., and Davis, R.W. 2011. Predicting foraging hot spots for marine mammals: An eco-physiological perspective. The Society for Marine Mammalogy Abstracts. Tampa FL, November 26 - December 2.

Williams, T.M. 2010. Variability in the dive response in active marine mammals. Invited speaker, Diving Marine Mammal Gas Kinetics Workshop. Woods Hole MA, April 2010.

Williams, T.M. 2008. Physiology and energetics in marine ecosystems. Invited speaker and organizer for the Symposium on Physiological Basis of Ecosystem Health. Experimental Biology, April 5-9, San Diego, CA.

Williams, T.M. and Zavanelli, M. 2008. Natural neuroprotection in the brains of marine mammals: why swimming dolphins don't stroke. Society for Integrative and Comparative Biology. Jan 2-6, San Antonio, TX.

Williams, T.M. 2007. Natural neuroprotection in marine mammals. Physiological Ecology Meeting. June 1-3, White Mountain Research Station, CA.

Williams, T.M. 2006. Survival Physiology: Reassessing why big, fierce animals are rare. 2006 American Physiological Society Conference on Comparative Physiology. Invited Plenary Talk. Oct 8-11, Virginia Beach, VA.

Williams, T.M. 2006. Foraging energetics and behavior of large, mobile predators: The cost of a stroke, step or flap. Invited symposium speaker, Proceedings of the Cambridge Symposium in Honor of John Croxall, April 6-9, Cambridge, England.

Williams, T.M. 2006. The physiology of surfing. Invited symposium speaker, 53rd Annual meeting of the American College of Sports Medicine, May 31-June 3, Denver, CO.

Williams, T.M. Rutishauser, M., Dunkin, R., and Quihuis, D. 2005. Variability in cetacean energetics: Do killer whales really have "killer appetites?" 16th Biennial Conference on the Biology of Marine Mammals, Dec 12-16, San Diego, CA.

Williams, T.M. 2005. Energetic and thermal challenges at depth: The marine mammal's dilemma. Symposium on Cardiorespiratory Physiology of Diving: Extreme physiology at Depth. XXXV International Congress of Physiological Sciences, March 31-Ap 5, San Diego, CA.

Williams, T.M., and Yeates, L. 2004. The Energetics of foraging in large mammals: A comparison of marine and terrestrial predators. Proceedings of the 3rd International Congress on Comparative Physiology and Biochemistry, Aug 7-13, KwaZulu, Natal, South Africa.

Williams, T.M. 2003. The collapse of pinnipeds and sea otter populations in the North Pacific Ocean: An ecological legacy of industrial whaling? Plenary Speaker, 15th Biennial Conference on the Biology of Marine Mammals, Dec 14-19, Greensboro, NC.

Williams, T.M. 2002. The effect of behavior on physiological dive capacity in marine mammals: What lies beneath. The Physiologist 45(4); 324.

Williams, T.M. 1999. Sink or swim strategies for low cost diving in marine mammals. American Zoologist 39(5): 4A.

Williams, T.M. and Hurley, W.C. 1999. Batteries not included: Marine mammal strategies for cost efficient underwater performance. Proceedings of the 11th International Symposium on Unmanned Untethered Submersible Technology (99-8-01).

Williams, T.M., and Yeates, L. 1999. Long-Term effects of oil contamination in Alaskan sea otters. Symposium on the Legacy of an Oil Spill – 10 years after the Exxon Valdez, pp. 20.

Williams, T.M. 1998. The evolution of cost efficient swimming in mammals. Physiological Ecology Meeting, Bishop, CA

Williams, T.M. 1996. Physiological specialization dictates cost efficient locomotion in mammals. American Physiological Society, Integrative Biology of Exercise, Vancouver, Canada.

Williams, T.M., LeBoeuf, B., Davis, R., Crocker, D., and Skrovan, R. 1996. Integrating behavior and energetics in diving marine mammals: New views using video technology. 5th European Conference on Wildlife Telemetry, Strasbourg, France.

Williams, T.M. 1995. Mammalian strategies for locomotor and energetic proficiency in the aquatic environment. Zool. Soc. of London, Regents Park, England.

Williams, T.M. 1995. Swimming energetics of marine mammals: Terrestrial mammals in wetsuits? 11th Biennial Conference on the Biology of Marine Mammals. Orlando, Florida.

Williams, T.M. 1993. Swimming and diving energetics of Bottlenose dolphins: Low cost locomotion by a thinking athlete. Am. Zoologist 33(4).

Williams, T.M., Shippee, S.F., Lawson, K.L., Chun, N.C., Friedl, W.A., and Haun, J.E. 1993. Non-steady swimming increases dive duration in Bottlenose dolphins. Tenth Biennial Conference on the Biology of Marine Mammals. Galveston, TX.

Williams, T.M., Davis, R.W., Castellini, M.A., Loughlin, T.R., Calkins, D.G., and Sease, J. 1993. The relationship between body condition and thermoregulatory costs in Steller sea lion pups. Tenth Biennial Conference on the Biology of Marine Mammals. Galveston, TX.

Williams, T.M., Friedl, W.A., and Haun, J.E. 1992. Assessing the Physiological Limits of Exercise Performance in Bottlenose Dolphins. The Physiologist 35(4):224.

Williams, T.M., Friedl, W.A., Haun, J.E., and Chun, N.K. 1992. Balancing Power and Speed in Bottlenose Dolphins (*Tursiops truncatus*). Recent Advances in Marine Mammal Science, The Zoological Society of London, England.

Williams, T.M., Friedl, W.A., and Haun, J.A. 1991. Swimming by Bottlenose dolphins (*Tursiops truncatus*): Odontocete Olympians or sedentary cetaceans. Ninth Biennial Conference on the Biology of Marine Mammals, Chicago, IL.

Kanatous, S., Williams, T.M., Tirpak, A.J., and Davis, R.W. 1991. Thermoregulation in pinnipeds: The heat recycling sea lion. Ninth Biennial Conference on the Biology of Marine Mammals, Chicago, IL.

Williams, T.M., Friedl, W.A., Fong, M.L., and Haun, J.E. 1991. Swimming in Bottlenose Dolphins (*Tursiops truncatus*): Aerobic and Anaerobic limits to Performance. J. Exp. Mar. Biol. 71(3):727-728.

Williams, T.M. and Friedl, W.A. 1990. Heat Flow Properties of Dolphin Blubber: Insulating Warm Bodies in Cold Water. Am. Zool. 30(4).

Williams, T.M. 1990. Evaluating the Long Term Effects of Crude Oil Exposure in Sea Otters: Laboratory and Field Observations. Symposium on the Effects of Oil on Wildlife, International Wildlife Research Council, Washington, DC, October 16-18.

Williams, T.M. 1990. Acute Toxicity and Pathology of Sea Otters and Harbor Seals Impacted by the Exxon Valdez Oil Spill. Southern California Academy of sciences, Dominguez Hills, CA, May 11-12.

Williams, T.M. 1990. Oil Spills and Information Flow. Panel Discussion, Pacific Outer Continental Shelf Region Information Transfer Meeting, Minerals Management Services, Santa Barbara, CA, May 7-9.

Williams, T.M., McBain, J., Wilson, R., and Davis, R. 1990. Clinical Evaluation and Cleaning of Sea Otters Impacted by the Oil Spill. Sea Otter Symposium USFWS, Anchorage, AK, April 17-19.

Williams, T.M. 1989. Acute Toxicity and Pathology of Crude Oil in Sea Otters and Seals of Prince William Sound: An Overview. Marine Mammal Conference, Pacific Grove, CA.

Williams, T.M. 1989. Acute Toxicity and Pathology of Spilled Prudhoe Bay Crude in Marine Mammals. Conference on the Alaskan Oil Spill and Human Health, NIEHS, July.

Williams, T.M. 1989. Marine Mammals: Limits to athletic performance during submergence. Invited lecture, International Union of Physiological Sciences, Helsinki, Finland, July.

Williams, T.M., and Martin, J. 1988. Adaptations of avian skeletal muscle for aquatic locomotion: Evidence from biopsies and P-NMR spectroscopy. Am. Zoologist 28(4).

Williams, T.M., Kooyman, G.L., and Croll, D.A. 1987. The Relationship between Metabolic Rate and Heart Rate of Swimming Harbor Seals. The Physiologist 30(4):189.

Williams, T.M. 1987. Respiratory and cardiovascular responses to exercise in harbor seals and sea lions. Workshop on Pinniped Energetics, December.

Williams, T.M., and Kastelein, R.A. 1987. Comparison of the insulation of California and Alaska sea otters. Marine Mammal Conference, December.

Kacirk, J.J., and Williams, T.M. 1987. A Method for the measurement of metabolic heat transfer from various body regions of ocean mammals (immersed). Cold Water Diving for Science Symposium, October.

Williams, T.M. 1986. Heart rate and voluntary breath-hold duration in swimming harbor seals. Am. Zoologist 26(4).

Williams, T.M. 1984. Energetics and hydrodynamic advantages of submerged swimming in sea otters. Am Zool. 24(3).

Williams, T.M., and Kooyman, G.L. 1983. Swimming locomotion of the sea otter (*Enhydra lutris*) and North America Mink (*Mustela vison*, Schreber). Twenty-ninth Congress of the International Union of Physiological Sciences, Sydney, Australia.

Williams, T.M., and Kooyman, G.L. 1983. Hydrodynamic and swimming performance characteristics of harbor seals (*Phoca vitulina*). Fifth biennial Conference on the Biology of Marine Mammals, Boston, MA.

Williams, T.M., Kooyman, G.L., and Davis, R. 1983. Breath-hold duration during sustained swimming in the harbor seal (*Phoca vitulina*). IUPS Satellite Symposium: Breath-hold diving and asphyxia, Port Stephens, Australia.

Williams, T.M. 1982. Thermoregulation during swimming in the mink, a semi-aquatic mammal. The Physiologist 25(4), 279.

Williams, T.M. 1980. A comparison of running and swimming energetics in the mink. Ann. Meeting, Am. Soc. Zoologists, Seattle, Am. Zool. 20(4), 909.

Williams, T.M. 1980. Energy metabolism of running minks in relation to speed and gait pattern. Am. Physiol. Soc., Toronto, The Physiologist. 23(4), 41.

Williams, T.M. 1980. Metabolism and heat storage in the North American Mink. Regional meeting, Division of Comparative Physiology. Am. Soc. Zool.

Books

Williams, T.M. 2012. *The Odyssey of KP2: An orphan seal, a marine biologist and the fight to save a species.* Penguin Press, NY. 300 pp. (hardcover, paperback in 2013).

Estes, J.A., Doak, D., DeMaster, D., Brownell, R. and Williams, T.M. (eds.) 2007. *Whales, Whaling and Ecosystems*. University of California Press, Berkeley, CA, 418 pp.

Williams, T.M. 2004. *The Hunter's Breath: On expedition with the Weddell Seals of Antarctica*. M. Evans and Co., Inc., New York. 289 pp.

Williams, T.M. and Davis, R.W. 1995. *Emergency Care and Rehabilitation of Oiled Sea Otters and Other Fur-bearing Marine Mammals*. University of Alaska Press, Fairbanks. 279 pp.

Book Chapters (recent with 12 additional references available on request)

Williams, T.M. 2018. Swimming. In: *Encyclopedia of Marine Mammals, 3*. B. Wursig, and J.G.M. Thewissen, K. Kovaks eds. Academic Press, San Diego, CA, pp. 971-979.

Estes, J.A., Tinker, M.T., Williams, T.M. 2017. Recent advances in the physiology, behavior and ecology of sea otters. *In* Biology and Conservation of the Musteloids (badgers, otters, skunks, raccoons and their kin). Oxford University Press, Oxford.

Kitchener, A., Melero, C., Williams, T.M. 2017. Mustelid form and function. *In* Biology and Conservation of the Musteloids (badgers, otters, skunks, raccoons and their kin). Oxford University Press, Oxford.

Williams, T.M, Maresh, J. 2016. Exercise Energetics. In Marine Mammal Physiology: Requisites for ocean living. Castellini, M.A., and Mellish, J., eds. CRC Press, Boca Raton, FL, pp. 47-68.

Helm, R.C., Costa, D.P., DeBruyn, T.D., O'Shea, T.J., Wells, R.S., and Williams, T.M. 2015. Overview of Effects of Oil on Marine Mammals. In *Handbook of Oil Spill Science and Technology.* Fingas, M., ed. John Wiley & Sons, Inc. Hoboken, N.J., pp. 455-476.

Williams, T.M. 2009. Swimming. In: *Encyclopedia of Marine Mammals, 2*. W.E. Perrin, B. Wursig, and J.G.M. Thewissen, eds. Academic Press, San Diego, CA, pp. 1140-1147.

Williams, T.M. 2007. Physiological and ecological consequences of extreme body size in whales. In: *Whales, Whaling and Ecosystems*. Estes, J.A., Doak, D., DeMaster, D., Brownell, R. and Williams, T.M., eds. University of California Press, Berkeley, CA, pp. 191-201.

Williams, T.M. and Worthy, G. 2002. Anatomy and physiology: The challenge of aquatic living. In: *Marine Mammal Biology: An Evolutionary Approach*. A.R. Hoezel, ed. Blackwell Science Ltd. Blackwell Publishers, London. pp. 73-97.

Williams, T.M. 1998. Physiological challenges in semi-aquatic mammals: Swimming against the energetic tide. In: *Behavior and Ecology of Riparian Mammals*. N. Dunstone and M. Gorman, eds. Cambridge University Press, Cambridge, England. pp. 17-30.

Williams, T.M., Shippee, S.F. and Rothe, M.J. 1996. Strategies for reducing foraging costs in dolphins. In: *Aquatic Predators*. S. Greenstreet and M.L. Tasker, eds. Blackwell Science Ltd., London. pp. 4-9.

Williams, T.M., O'Connor, D.J., and Nielsen, S.W. 1995. The effects of oil on sea otters: Histopathology, toxicology and clinical history. In: *Emergency Care and Rehabilitation of Oiled Sea Otters.* T.M. Williams and R.W. Davis, eds. University of Alaska Press, Fairbanks. pp. 3-22.

Williams, T.M., Davis, R.W., McBain, J.F., Tuomi, P.A., Wilson, R.K., McCormick, C.R. and Donoghue, S. 1995. Diagnosing and treating common clinical disorders in sea otters. In*: Emergency Care and Rehabilitation of Oiled Sea Otters.* T.M. Williams and R.W. Davis, eds. University of Alaska Press, Fairbanks. pp. 59-94.

Williams, T.M., McBain, J.F., Tuomi, P.A. and Wilson, R.K.. 1995. Initial clinical evaluation, emergency treatments and assessment of oil exposure. In*: Emergency Care and Rehabilitation of Oiled Sea Otters.* T.M. Williams, and R.W. Davis, eds. University of Alaska Press, Fairbanks. pp. 45-58.

Tuomi, P.A., and Williams, T.M. 1995. Rehabilitation of pregnant sea otters and females with newborn pups. In: *Emergency Care and Rehabilitation of Oiled Sea Otters.* T.M. Williams and R.W. Davis, eds. University of Alaska Press, Fairbanks. pp. 121-132.

Williams, T.M. 1995. Wildlife triage. In: *Emergency Care and Rehabilitation of Oiled Sea Otters.* T.M. Williams and R.W. Davis, eds. University of Alaska Press, Fairbanks. pp. 155-158.

Williams, T.M., Antonelis, G.A. and Balke, J. 1994. Health evaluation, rehabilitation, and release of oiled harbor seal pups. In*: The Impact of the Exxon Valdez Oil Spill on Marine Mammals*. T. Loughlin, ed. Academic Press. San Diego, CA. pp. 227-242.

Williams, T.M. 1987. Approaches for the Study of Exercise Physiology and Hydrodynamics in Marine Mammals. In: *Marine Mammal Energetics.* T. Huntley, D. Costa, M. Castellini, and G. Worthy, eds. Marine Mammal Journal Special Publication. Lawrence, Kansas. pp. 127-145.

Popular Articles/Children's Books (other)

Markovics, J.L. (T.M. Williams consultant) 2009. Weddell Seal: Fat and Happy. Bearport Publishing, New York . 32 pp. (science for slow readers).

Rodriguez, A.M. (T.M. Williams consultant) 2009. Secrets of the Sleepless Whales. Enslow Publishers, Inc., Berkeley Heights, NJ. 48 pp.

Williams, T.M. 2003. Sunbathing in Antarctica: The Weddell seals of summer. Natural History magazine. NY

Williams, T.M. 2000. Cetacean Olympians in *Dolphins* (T. Cahill, ed.) National Geographic Society Press, Washington, DC. Pp. 187.

Williams, T.D, and Williams, T.M. 1996. The role of rehabilitation in Sea Otter conservation efforts. Endangered Species Update 13:50-52.

Williams, T.M. 1992. Tiger on a Treadmill. Ranger Rick 26(6):34-37.

Davis, T.M., and Williams, T.M. 1991. The saga of the Alaska Sea Otters. The World and I 6(3):314-319.

Williams, T.M. 1990. Evaluating the Long Term effects of Crude oil exposure in Sea Otters: Laboratory and Field Observations. Special Publication of International Wildlife Research. 13 pp.

Williams, T.M. 1988. Cetacean Olympians. Cetus 8(1):2-6.

Technical Reports

Williams, T.M., Ponganis, P, Fahlman, A. 2018. Report on the Current Stats and Future Directions of Marine Mammal Diving Physiology: Workshop proceedings. For the Office of Naval Research, 124 pp.

Steller Sea Lion Recovery Team (T.M. Williams member) 2006. Steller Sea Lion Recovery Plan. Report to the National Oceanic and Atmospheric Administration-NMFS Office of Protected Species. 284 pp.

Williams, T.M. and Davis, R.W. 1989. Research Projects at the Sea Otter Rescue Centers: A Preliminary Report. Exxon Environmental Report. 36 pp.

Davis, R.W., Williams, T.M., and Awbrey, F.T. 1988. Sea Otter Spill Avoidance Study. Minerals Management Service, OCS Study MMS 88-0051. 65 pp.

Williams, T.M. 1987. The energetics and biomechanics of running in felids and canids. Report to The Whitehall Foundation. 12 pp.

Williams, T.M., Kastelien, R., Davis, R., and Thomas, J. 1986. Procedures for cleaning sea otter fur contaminated with fresh or weathered crude oil: Thermal implications of contamination and cleaning . In *Sea otter spill mitigation study*. Report to Minerals Management Service, #MMS 86009 OCS Study, 218 pp.

Participation in Public Lectures or Forums and Invited Research Seminars

2019	Plenary speaker, August Krogh lecture, Experimental Biology Meeting, Orlando, FL, April 6-9
2018	Invited Symposium speaker, American Physiological Society, Comparative Physiology Meeting, New Orleans, LA, October 25-28
2018	Invited Speaker, Duke Marine Laboratory, NC, October 21-25
2017	Plenary speaker, International Mammalogical Meeting, Perth, Australia
2017	Invited speaker, Julius Thomas Hansen Lectureship Series, University of California-Berkeley, April 12-14.
2016	Plenary speaker, Society of Integrative and Comparative Biology, Portland, OR.
2015	Invited speaker- Campus Read Program, Boise State University, Boise, ID
2013	Invited speaker, International Mammalogical Meeting, Belfast, Ireland
2013	Distinguished Female Scientist/Visitor, University of New South Wales, Australia
2012	Sitka WhaleFest Invited speaker and public outreach teacher, Sitka, AK
	Invited Speaker, Oiled Wildlife Care Network Annual Workshop, Santa Cruz, CA
2009	Distinguished Ecologist Series, Colorado State University
	The Laurence Irving- Per Scholander Memorial Lecture Series Visiting Professor
2008	San Diego Zoological Society. Invited speaker in symposium, State of Endangered Species: Climate Change Wildlife Impacts
	Miller Institute Interdisciplinary Symposium Speaker, University of California- Berkeley
	The Art of Exploration, featured speaker, San Antonio, TX
2007	National Geographic Live, Invited speaker, Washington DC
2006	American College of Sports Medicine, invited speaker annual meeting
	Northwest Pacific Fisheries Research Council
2005	California Academy of Sciences, Biology Teacher's Symposium
	University of Wyoming, Laramie, invited speaker
2003	Florida Atlantic University, Boca Raton, invited speaker
	University of North Carolina, Wilmington, NC
2002	Eckland Biology Laboratory, McMurdo Station, Antarctica
	Duke University, Beaufort Laboratory
2001	Eckland Biology Laboratory, McMurdo Station, Antarctica
	Schweppe Invited Speaker, University of Texas, Corpus Christi, TX
2000	Scripps Institution of Oceanography, UCSC
	IBM Science and Technology Conference 2000
1999	Eckland Biology Laboratory, McMurdo Station, Antarctica
1998	University of Alaska, Fairbanks/Seward Sealife Center
	Office of Naval Research, Washington, D.C.

	Eckland Biology Laboratory, McMurdo Station, Antarctica
1997	University of Alaska, Fairbanks
	Eckland Biology Laboratory, McMurdo Station, Antarctica
1996	Navy Postgraduate School, Monterey, CA
	University of California, Davis Veterinary School
1995	Hopkins Marine Station
	University of Durham
	Zoological Society of London
1994	National Zoological Society, Washington, DC
	University of Maryland, Dept. of Zoology
	University of Aberdeen, Scotland
1993	University of California, Santa Cruz, Dept. of Biology
	Office of Naval Research
	Texas A&M University, Dept. of Marine Biology
1992	Zoological Society of London, England
	University of California, Davis Veterinary School
	University of Hawaii, Dept. of Zoology
	Scripps Institution of Oceanography, Physiological Research Lab
1991	University of Birmingham, Birmingham, England
	University of Hawaii Medical School
	University of Portland
	Seattle Aquarium
1990	Monterey Bay Aquarium
	Wildlife Rehabilitation Council, Washington, DC
	Minerals Management Service, ITM, Santa Barbara, CA
1989	National Institutes of Environmental Health, Seattle Meeting
	University of Las Vegas
	IUPS, Finland
	American Cetacean Society
	Scripps Institution of Oceanography
1988	University of Pennsylvania Medical School
	University of California, Santa Cruz
1987	UCSD Medical School
	University of San Diego
	San Diego State University
	Zoological Society of San Diego

Sampling of Scientific Expeditions and Field Work

2015-present	Mpala Research Station, Kenya, Energetics of African lions
2014-present	Greenland, Cardiovascular Physiology of Diving Narwhals
2014-present	McMurdo Station, Antarctica, Navigation in Weddell Seals
2008-2011	McMurdo Station, winfly; Hunting in Darkness by Weddell Seals
2007	South Africa and Namibia: Water Use by African Elephants
2004-2006	San Nicolas Island, CA; Energetics of Growth in California Sea Lions
	Grand Bahama Islands; Variability in the Dive Response of Bottlenose Dolphins
2005	Lopez Mateos, Mexico; Sampling of by-catch cetaceans
2004	Namibia, Field Sites for Physiological Studies of Large Mammals
2003	Adak Island, AK; Field work on marine mammal abundance
1997-2002	McMurdo Sound, Antarctica Expedition; Foraging Behavior and Physiology of Weddell

	Seals
1994-5	Grand Bahama Islands, Thermal Physiology of Bottlenose Dolphins
1990-1995	Aleutian Islands and Gulf of Alaska, Body Condition in Steller Sea Lions
1990-1994	Hawaiian Islands, Thermal Physiology of Warm Water Dolphins
1988-90	Valdez Alaska and Prince William Sound; Toxicological Effects of the Exxon Valdez Oil Spill on Alaskan Sea Otters
1985	Windhoek, Namibia; Body condition and running morphology of African Cheetahs

Graduate Students

Student	Department	Degree Program	Year	Co-Sponsor
Lillian Carswell	Biology	Ph.D.	2019-	
Jessica Kendall-Bar	Biology	Ph.D.	2017-	Costa
Jason John	Biology	Ph.D.	2014-	
Anthony Pagano	Biology	Ph.D.	2012-2018	
Caleb Bryce	Biology	Ph.D.	2011-2017	
Jessica Meir	Scripps IO	Ph.D.	2008-2014	Ponganis
Nicole Thometz	Biology	Ph.D.	2008-2014	Estes
Jennifer Maresh	Biology	Ph.D.	2006-2014	
Robin Dunkin	Biology	Ph.D.	2004-2013	
Daniel Monson	Biology	Ph.D.	2002-2009	Estes
Heather Mostman	Biology	Ph.D.	2002-2008	
Laura Yeates	Biology	Ph.D.	2000-2006	
Dawn Noren	Biology	Ph.D.	1997-2002	
Shawn Noren	Biology	Ph.D.	1997-2002	
Matt Rutishauser	Biology	Masters	1997-2001	
Jeanine Scaramozzino	Biology	Masters	1997-2000	
Scott Shaffer	Biology	Ph.D.	1996-2000	Costa
Dawn Noren	Ocean Sci	Masters (1997)	1995-1997	
Shawn Noren	Ocean Sci	Masters (1997)	1995-1997	
Randolph Skrovan	Ocean Sci	Masters (1998)	1995-1998	
Suzanne Kohin	Biology	Ph.D. (1998)	1994-1998	Ortiz
Scott Shaffer	Ocean Sci	Masters (1996)	1994-1996	
Elisif Brandon	Texas A&M	Ph.D.	1993-2000	Davis

Postdoctoral Fellows

Nicole Thometz	(2014)
Robin Dunkin	(2013)
Suzanne Kohin	(1998)
Shawn Noren	(2009)
Laura Yeates	(2009)
Robin Dunkin	(2013)

UCSC STUDENT MENTORING

16 Ph.D. students (3 current), 6 Masters students, 6 post-doctoral scholars, > 200 in lab undergraduate students in the Marine Mammal Physiology Program

NICOLE M. THOMETZ, PHD

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EDUCATION

Ph.D. Ecology & Evolutionary Biology. University of California Santa Cruz — 2014
Advisors: Dr. Terrie M. Williams & Dr. James A. Estes

B.S. Biology; philosophy minor. University of Portland, Portland, OR — 2008

PROFESSIONAL POSITIONS

Assistant Professor — Department of Biology, University of San Francisco — 2017 - present

Research Associate — Institute of Marine Sciences, UC Santa Cruz — 2017 - present

Postdoctoral Scholar — Institute of Marine Sciences, UC Santa Cruz — 2016 - 2017
Advisor: Dr. Colleen Reichmuth

Postdoctoral Researcher — Ecology & Evolutionary Biology Department, UC Santa Cruz — 2014 - 2016
Advisor: Dr. Terrie M. Williams

AWARDS, GRANTS, & HONORS

NOAA Alaska Pinniped Research Program FY2016 [[redacted]] — 2016 - 2019
PI: Colleen Reichmuth, Co-PI's: **Nicole M. Thometz** & David Rosen

NOAA Alaska Pinniped Research Program FY2015 [[redacted] — 2015 - 2016
PI: Colleen Reichmuth; Postdoc: **Nicole M. Thometz**

Chancellor's Dissertation-Year Fellowship [[redacted]] — 2013-2014

NSF Doctoral Dissertation Improvement Grant [[redacted]] — 2012

Rebecca & Steve Sooy Graduate Fellowship [[redacted]] — 2012

National Geographic Young Explorers Grant [[redacted]] — 2011

Myers Trust Award [[redacted] — 2009

PROFESSIONAL SOCIETIES

Society for Integrative and Comparative Biology

Society for Marine Mammolgy

PEER-REVIEWED PUBLICATIONS

Thometz NM, Rosen DAS, **Hermann-Sorensen, H,** Russell, B., Reichmuth, CR (In prep) "*Seasonal energetics of ice-dependent Arctic seals reveal the metabolic consequences of different molting strategies.*" For submission to Journal of Experimental Biology.

Thometz NM, Rosen DAS, Reichmuth, CR (In prep) "*Environmental and ontogenetic effects on energy intake and allocation in spotted seals (Phoca largha).*" For submission to Aquatic Mammals.

Goertz, CEC, Reichmuth, C, **Thometz, NM,** Ziel, H, Boveng, P (2019) "*Comparative health assessments of Alaskan ice seals*." Frontiers in Veterinary Science. 6(4):1-15. doi: 10.3389/fvets.2019.0004

Thometz, NM, Dearolf, JL, Dunkin, RC, Noren, DP, Holt, MM, **Sims, OC, Cathey, BC,** Williams, TM (2018) "*Comparative physiology of vocal musculature in two odontocetes, the bottlenose dolphin (Tursiops truncatus) and the harbor porpoise (Phocoena phocoena).*" Journal of Comparative Physiology B. 188(1): 177-193. doi: 10.1007/s00360-017-1106-5.

Thometz, NM, Kendall, TL, Richter, B, Williams, TM (2016) "*The high cost of reproduction in sea otters necessitates unique physiological adaptations.*" The Journal of Experimental Biology. 219(15): 2260-2264. doi: 10.1242/jeb.138891.

Thometz, NM, Staedler, MM, Tomoleoni, JA, Bodkin, JA, Bentall, GB, Tinker, MT (2016) *"Trade-offs between energy maximization and parental care in a diving central place forager, the sea otter (Enhydra lutris)."* Behavioral Ecology. 27(5): 1552-1566. doi: 10.1093/beheco/arw089.

Thometz, NM, Williams, TM, Murray, MJ (2015). "*Ontogeny of oxygen storage capacity and diving ability in southern sea otters (Enhydra lutris nereis): Costs and benefits of large lungs.*" Physiological and Biochemical Zoology. 88(3): 311-327. doi: 10.1086/681019.

Williams, TM, Fuiman, LA, Kendall, TL, Berry, P, Richter, B, Noren, SR, **Thometz, NM**, Shattock, MJ, Farrell, E, Stamper, AM, Davis, RW (2015). *"Exercise at depth alters bradycardia and incidence of cardiac anomalies in deep-diving marine mammals."* Nature Communications. 6(6055): 1-9. doi: 10.1038/ncomms7055.

Thometz, NM, Tinker, MT, Staedler, MM, Mayer, KA, Williams, TM (2014). *"Energetic demands of immature sea otters from birth to weaning: Implications for maternal costs, reproductive behavior, and population-level trends."* The Journal of Experimental Biology. 217(12): 2053-2061. doi: 10.1242/jeb.099739.

Undergraduate author; Graduate student mentee

OTHER PUBLICATIONS

Noren, DP, Holt, MM, Dunkin, RC, **Thometz, NM**, Williams, TM (2017) *"Comparative and cumulative energetic costs of odontocete responses to anthropogenic disturbance*." Proceedings of Meetings on Acoustics. Acoustical Society of America. 27:1-12.

Thometz, NM (2014). *"Ontogeny of Energetic Demand and Diving Ability in the Southern Sea Otter (Enhydra lutris nereis) and Implications on Diving and Foraging Behavior."* Doctoral Dissertation. University of California, Santa Cruz.

Thometz, NM (2014) *"Sea Otter Motherhood: and you thought you had it rough?"* Friends of the Sea Otter Fall Newsletter, p. 6-7. www.seaotters.org.

Tinker, MT, Jessup, D, Staedler, M, Murray, M, Miller, M, Burgess, T, Bowen, E, Miles, K, Tomoleoni, J, **Thometz, NM**, Tarjan, L, Golson, E, Batac, F, Dodd, E, Berberich, E, Kunz, J, Bentall, G, Nicholson, T, Newsome, S, MacCormick, H, Melli, A, Johnson, A, Henkel, L, Kreuder-Johnson, C, Conrad, P (2013). *"Sea Otter Population Biology at Big Sur and Monterey California: Investigating the Consequences of Resource Abundance and Anthropogenic Stressors for Sea Otter Recovery"*. Final Report to California Coastal Conservancy and U.S. Fish and Wildlife Service. University of California Santa Cruz, CA. 242 pages.

SELECTED PUBLIC SPEAKING

Thometz, NM, Kendall, TL, Richter, BP, Williams, TW (2019) "Reproductive physiology and energetics of sea otters." Sea Otter Conservation Workshop XI, Seattle Aquarium, Seattle, WA.

Thometz, NM, Rosen, DAS, Reichmuth, CR (2019) "*Seasonal energetics of ice-dependent Arctic seals reveal the metabolic consequences of different molting strategies.*" Society for Integrative and Comparative Biology (SICB) Annual Meeting, Tampa, FL USA.

Tengler, M, Bryan, A, Reichmuth, CR, **Thometz, NM** (2019) "*Physiological development of locomotor muscles influence diving capacities in free-ranging bearded seals.*" Society for Integrative and Comparative Biology (SICB) Annual Meeting, Tampa, FL USA.

Thometz, NM, Reichmuth, CR, Rosen, DAS (2018) "*PHOCAS: Physiology and Health of Cooperating Arctic Seals.*" Alaska SeaLife Center - Ocean Science Symposium, Seward, Alaska.

Thometz, NM, Reichmuth, CR (2018) "*Physiological Adaptations for Diving in the Bearded Seal.*" Society for Integrative and Comparative Biology (SICB) Annual Meeting, San Francisco, CA USA. [Session Chair]

Thometz, NM, Reichmuth, CR, Russell, B, Rosen, DAS (2017) "*Comparative Energetics of Ringed, Bearded, and Spotted Seals.*" 22nd Biennial Conference on The Biology of Marine Mammals, Halifax, Nova Scotia, Canada.

Thometz, NM (2017) "*Using physiological research to inform the conservation of marine mammals*." 'Science on Tap' monthly public science talk series, organized by the University of California Women in Science and Engineering, and hosted at The Crepe Place, Santa Cruz, CA.

Thometz, NM, Rosen, DAS, Reichmuth, C (2017) *"Patterns of Energy Intake in Captive Spotted Seals (Phoca largha) Provide Insight into Physiologically Sensitive Life-Stages*." Society for Integrative and Comparative Biology (SICB), Annual Meeting, New Orleans, LA.

Noren, DP, Holt, MM, Dunkin, RC, **Thometz, NM**, Williams, TM (2016) *"Comparative and cumulative energetic costs of odontocete responses to anthropogenic disturbance*." Fourth International Conference on the Effects of Noise on Aquatic Life, Dublin, Ireland.

Thometz, NM, Kendall, TL, Richter, BP, Williams, TW (2016) "*Reproductive energetics in the sea otter*." Southern Sea Otter Research Alliance Meeting, Santa Cruz, CA, USA.

Thometz, NM, Dunkin, RC, Noren, DP, Holt, MM Williams, TM (2016) "*Aerobic and Anaerobic Capacities of Sound Production Muscles in Two Odontocetes."* Society for Integrative and Comparative Biology (SICB) Annual Meeting, Portland, OR, USA. [Session Chair]

Thometz, NM, Kendall, TL, Richter, BP, & Williams, TW (2015) "*The metabolic roller coaster: Reproduction in sea otters (Enhydra lutris) necessitates unique physiological adaptations*." 21st Biennial Conference on The Biology of Marine Mammals, San Francisco, CA, USA.

Tinker, MT, **Thometz, NM,** *et al.* (2015) "*Between a rock (crab) and a sharp place: The curious conundrum of the southern sea otter, and some unexpected silver linings*." 21st Biennial Conference on The Biology of Marine Mammals, San Francisco, CA, USA.

Tomoleoni, JA, **Thometz, NM**, Staedler, MM, Tinker, MT (2015). "*A range wide examination of southern sea otter diving behavior using 15 years of TDR data."* 21st Biennial Conference on The Biology of Marine Mammals, San Francisco, CA, USA.

John, J, Blackwell, S, Heide-Jorgensen, MP, Southall, B, Friedlander, A, **Thometz, NM**, Williams, TM (2015) "*Measuring instantaneous energetic costs in highly maneuverable marine mammals*." 21st Biennial Conference on The Biology of Marine Mammals, San Francisco, CA, USA.

Dunkin, R, Noren, D, Holt, M, **Thometz, NM**, Williams, TW, Jeffress, J, Cranford T (2015) "*Using CT scans to estimate mass of sound producing muscles in odontocetes: Implications for scaling the cost of vocal modification*." 21st Biennial Conference on The Biology of Marine Mammals, San Francisco, CA, USA.

Williams, TW, Richter, B, Kendall, TL, Ribeiro-French, C, John, J, **Thometz, NM** (2015) "*Degrees of physiological freedom: A new analytical tool for determining 3-dimensional critical habitats for marine mammals.*" 21st Biennial Conference on The Biology of Marine Mammals, San Francisco, CA, USA.

Thometz, NM, Staedler, MM, Tomoleoni, JA, Tinker, MT (2015) *"Using Time-Depth Recorders to Identify Sources of Variation in Southern Sea Otter Diving Behavior throughout their Current Range."* Sea Otter Conservation Workshop IX, Seattle Aquarium, Seattle, WA.

Staedler, MM, **Thometz, NM**, Tomoleoni, JA, Tinker, MT (2015) *"Fourteen Years of Time-Depth Recorder Activity Budget Data in Southern Sea Otters."* Sea Otter Conservation Workshop IX, Seattle Aquarium, Seattle, WA.

Kendall, TL, Richter, BP, Ribero-French, C, **Thometz, NM**, Williams, TM (2015) *"The Marine Mammal Physiology Project at Long Marine Lab Sea Otter Program."* Sea Otter Conservation Workshop IX, Seattle Aquarium, Seattle, WA.

Thometz, NM, Richter, BP, Kendall, TL, Williams, TW (2015) *"Physiological Capacity for Diving in the Critically Endangered Hawaiian Monk Seal."* Society for Integrative and Comparative Biology (SICB) Annual Meeting, West Palm Beach, FL. [Session Chair]

Thometz, NM (2014) "*Energetic Demands of Immature Sea Otters from Birth to Weaning: Implications for maternal costs, reproductive behavior, and population-level trends."* UCSC Graduate Science Communication Program – Reporting and writing science course. Santa Cruz, CA. *<u>INVITED SPEAKER</u>

Kendall, TL, Richter, BP, **Thometz, NM**, Williams, TW (2014) *"Aerobic Dive Limits of Hawaiian Monk Seals: A Physiological Metric for Establishing Ideal Foraging Habitat for an Endangered Species."* 42nd Annual International Marine Animal Trainer's Association Conference, Orlando, FL.

Thometz, NM (2014) *"An Energetic Life History of the Smallest Marine Mammal: the Sea Otter."* PhD Defense Seminar, UC Santa Cruz, Long Marine Lab – Center for Ocean Health, Santa Cruz, CA.

Thometz, NM, Tinker, MT, Staedler, MM, Tomoleoni, JA, Williams, TM (2014) *"The Diving and Foraging Behavior of Sea Otters in Big Sur and Monterey, CA."* Southern Sea Otter Research Alliance Meeting, Santa Cruz, CA.

Thometz, NM, Tinker, MT, Staedler, MM, Williams, TM (2013) *"Diving and Foraging Behavior in Southern Sea Otters in Resource Limited Habitats: are sea otters pushing their physiological limits to survive?"* 20th Biennial Conference on The Biology of Marine Mammals, Dunedin, New Zealand.

Thometz, NM, Tinker, MT, Staedler, MM, Williams, TM (2013) *"Diving and Foraging Behavior in Southern Sea Otters in Resource Limited Habitats: are sea otters pushing their physiological limits to survive?"* The CA Student Chapter of the Society for Marine Mammology 2013 Meeting, Santa Cruz, CA.

Thometz, NM (2013) *"Ontogeny of Oxygen Storage Capacity and Diving Ability in Southern Sea Otters (Enhydra lutris nereis)."* California Department of Fish and Wildlife Lunchtime Seminar Series, Santa Cruz, CA. *<u>INVITED SPEAKER</u>

Thometz, NM (2013) *"Development of Diving and Foraging Ability in the Southern Sea Otter (Enhydra lutris nereis)."* University of California, Santa Cruz - Graduate Research Symposium, Santa Cruz, CA.

Thometz, NM (2013) *"Development of Diving and Foraging Ability in the Southern Sea Otter (Enhydra lutris nereis)."* Sea Otter Conservation Workshop VIII, Seattle Aquarium, Seattle, WA.

Thometz, NM & Williams, TM (2013) *"Ontogeny of Oxygen Storage Capacity and Diving Ability in Southern Sea Otters (Enhydra lutris nereis)."* Society for Integrative and Comparative Biology (SICB) Annual Meeting, San Francisco, CA.

Thometz, NM (2012) *"The Ontogeny of Metabolic Demands in Southern Sea Otters."* Southern Sea Otter Research Update Meeting, Santa Cruz, CA.

Thometz, NM (2011) *"Physiological Development of the Southern Sea Otter: implications for energetic demand, diving ability, and foraging ecology."* Sea Otter Conservation Workshop VII, Seattle Aquarium, Seattle, WA.

Thometz, NM (2011) *"Physiological Development of the Southern Sea Otter: Implications for energetic demand, diving ability, and foraging ecology."* Dissertation Proposal Defense Seminar, Long Marine Lab – Center for Ocean Health, UC Santa Cruz, CA.

Thometz, NM (2010) *"The Physiological Capacities of the Southern Sea Otter - Preliminary Data, Current Research, and Future Directions."* Southern Sea Otter Research Alliance Meeting, Santa Cruz, CA.

Thometz, NM (2009) *"Little Pup in a Big Ocean—The challenging lives of young sea otters and their journey to adulthood."* Sea Otter Awareness Week Seminar Series, CSU - Monterey Bay, CA. *INVITED SPEAKER

Thometz, NM (2009) *"Assessment of the Physiological Capacities of the Southern Sea Otter from Birth to Senescence." Monterey Bay Aquarium Lunchtime Seminar Series, Monterey, CA. *INVITED SPEAKER*

Thometz, NM & Williams, TM (2009) "Assessing aerobic capacity in immature sea otters: the challenge of transitioning to independent foraging." Southern Sea Otter Research Alliance Meeting, Santa Cruz, CA.

Undergraduate author; Graduate student mentee

SELECTED POSTER PRESENTATIONS

Reichmuth, C, **Thometz, NM,** Russell, B, **Hermann-Sorensen, H**, Rosen, DAS (2019). "*Molting Strategies and Seasonal Energetic Requirements of Spotted, Ringed, and Bearded Seals*." Alaska Marine Science Symposium (AMSS), Anchorage, AK.

Midkiff, BM, Dearolf, JL, Thometz, NM, (2019) "*Comparison of glycolytic metabolism in bottlenose dolphin (Tursiops truncatus) and harbor porpoise (Phocoena phocoena) vocal muscles*." Society for Integrative and Comparative Biology (SICB) Annual Meeting, Tampa, FL USA.

Ballard, EJ, Barrett, LM, Dearolf, JL, **Thometz, NM,** Bryan, A, Reichmuth, C (2019) "*Hybrid fibers in the bearded seal (Erignathus barbatus) longissimus dorsi muscle*." Society for Integrative and Comparative Biology (SICB) Annual Meeting, Tampa, FL USA.

Hartwick, M, Reichmuth, C, **Thometz, NM** (2019) "*Evaluating seasonal changes in body condition for spotted, ringed and bearded seals*." Society for Integrative and Comparative Biology (SICB) Annual Meeting, Tampa, FL USA.

Thometz, NM, Rosen, DAS, Reichmuth, C (2018) "*Ice Seal Energetics: Measuring seasonal changes in metabolism for ringed, bearded, and spotted seals.*" Alaska Marine Science Symposium (AMSS), Anchorage, AK.

Hermann-Sorensen, H, Ruscher-Hill, B, Tengler, M, Bryan, A, Reichmuth, C, **Thometz, NM** (2018) "*Aerobic and Anaerobic Properties of Bearded Seal Locomotor Muscle*." Society for Integrative and Comparative Biology (SICB) Annual Meeting, San Francisco, CA USA.

Barrett, LM, Dearolf, JL, **Thometz, NM**, Bryan, A, Reichmuth, CR (2018) "Fiber-type composition of bearded seal (Erignathus barbatus) locomotor muscle." Society for Integrative and Comparative Biology (SICB) Annual Meeting, San Francisco, CA USA.

Thometz, NM, Rosen, DAS, Russell, B, Reichmuth, C (2017) "*Patterns of Energy Intake and Metabolism in Spotted Seals (Phoca largha) Provide Insight into Physiologically Sensitive Life-Stages*." Alaska Marine Science Symposium, Anchorage, AK.

Goertz, C, Tuomi, P, Woodie, K, Belovarac, J, Rouse, N, **Thometz, NM,** Reichmuth, C (2017) "*Clinical findings from stranded ice-dependent Arctic seals."* Alaska Marine Science Symposium, Anchorage, AK.

Soo, EM, Dearolf, JL, **Thometz, NM**, Dunkin, RC, Williams, TW, Noren, DN, Holt, MM (2017) "*Myosin heavy chain expression of cetacean vocal muscles.*" Society for Integrative and Comparative Biology (SICB), Annual Meeting, New Orleans, LA.

Goertz, C, Tuomi, P, Woodie, K, Belovarac, J, Rouse, N, **Thometz, N,** Reichmuth, C (2016) *"Clinical findings from stranded ice-dependent Arctic seals."* National Marine Animal Health and Stranding Network Conference, West Virginia, USA.

Goertz, C, Casper, D, Johnson, S, **Thometz, N**, Reichmuth, C (2016) "*Baseline measures of health for ice-dependent Arctic seals.*" 47th Annual International Association for Aquatic Animal Medicine (IAAAM) Meeting and Conference, Virginia Beach, VA.

Reichmuth, CR, **Thometz, NM**, Rosen, D, Goertz, C (2016) "*Comparative measures of health and physiology for ice-dependent Alaskan Seals.*" Alaska Marine Science Symposium (AMSS), Anchorage, AK.

Williams, TM, **Thometz, NM**, Blackwell, S, John, J, Heide-Jorgenson, MP (2014) *"High Risk Behaviors in Marine Mammals: Linking biomechanics to cardiac variability in fast and slow swimmers."* Office of Naval Research (ONR) Marine Mammal & Biology Program Review, Alexandria, VA.

Thometz, NM, Williams, TM, Tinker, MT, & Staedler, MM (2011) *"A longitudinal assessment of the ecological implications of heightened energetic demands of immature southern sea otters (Enhydra lutris neres)."* 19th Biennial Conference on the Biology of Marine Mammals, Tampa, FL.

Undergraduate author; Graduate student mentee

STUDENT MENTORING

Thometz Lab Graduate Students:

Michelle Hartwick, MS Student (Biology) Aug 2018 – present
Mariah Tengler, MS Student (Biology) Jan 2018 – present

Thometz Lab Undergraduate Research Assistants:

Bensu Tangil, Biology Major, USF Class of 2020 Sept 2018 – present
Amanda Telfer, Biology Major, USF Class of 2020 Sept 2018 – present
Lexy Anderson, Biology Major, USF Class of 2020 Aug 2018 – present
Audrey Sun, Biology Major, USF Class of 2020 Feb 2018 – present
Esther Grady, Biology Major, USF Class of 2019 Oct 2017 – present

Graduate Student Mentoring & Committees:

Dennis Hicks, MS Student (Chemistry), USF Aug 2018 – present
Madelene Shehan, MS Student (Biology), USF Aug 2017 – present
Brandi Ruscher-Hill, MS Student (Ocean Sciences), UC Santa Cruz Jan 2017 – present
Holly Hermann-Sorensen, MS Student (Ocean Sciences), UC Santa Cruz Aug 2016 – present

Undergraduate Honors Thesis Committees:

James Hurst-Hopf, Biology Major, USF Class of 2018 Aug 2017 – June 2018

TEACHING EXPERIENCE

Courses Taught:

University of San Francisco: August 2017 - present

BIOL 319: Ecology
BIOL 105L: General Biology I Laboratory
BIOL 315: Biology of Marine Mammals
BIOL 316: Biology of Marine Mammals Laboratory
BIOL 350: Comparative Animal Physiology

BIOL 351: Comparative Animal Physiology Laboratory

University of California, Santa Cruz: Sept 2008 - July 2017

BIOE 133: Exercise Physiology
BIOE 133L: Exercise Physiology Laboratory
BIOE 107: Ecology
BIOE 131: Animal Physiology
BIOE 131L: Animal Physiology Laboratory

Teaching Assistantships (UC Santa Cruz):

BIOE 107: Ecology (Lecture/Discussion Section)
BIOE 131: Animal Physiology (Lecture/Lab)
OCEA 01: The Oceans (Lecture/Lab)

Other Relevant Experience:

Institute for Science and Engineering Educators Jan-Oct 2015

Professional Development Program (PDP) A flexible, year-long program for scientists at the early stages of their careers. Participants attend teaching workshops, join design teams, and teach a program or course at the end of each year. The PDP focuses on inquiry based learning at the college level, with a special emphasis on equity and inclusion. Participants learn a variety of inventive teaching strategies that can be applied to a range of teaching venues and leave the program as highly trained, innovative, and reflective scientist-educators.

SELECTED MEDIA COVERAGE

"Sea otter mums' metabolic rate rockets." *Inside JEB*, The Journal of Experimental Biology. Published online August, 3 2016 by Kathryn Knight. http://jeb.biologists.org/content/219/15/2229.1

"The Demands of Sea Otter Motherhood Prove Costly". Nature World News. Published online June 16th, 2014 by Jenna Lacurci. http://www.natureworldnews.com/articles/7603/20140616/the-demands-of-sea-otter-motherhood-prove-costly.htm

"It's Tough to be a Sea Otter Mom". *Quirks & Quarks, CBC Radio*. June 14, 2014. http://www.cbc.ca/quirks/2014/06/14/2014-06-14-2/

"It's hard being a sea otter mom." *ScienceNews.org*. Published online June 13, 2014 by Sarah Zielinski. https://www.sciencenews.org/blog/wild-things/it%E2%80%99s-hard-being-sea-otter-mom

"Sea Otter Moms Risk Lives to Raise Babies." *National Geographic*, Weird & Wild Blog. Published online June 11, 2014 by Katie Langin. http://newswatch.nationalgeographic.com/2014/06/11/sea-otters-animals-science-oceans-mothers-babies-young/.

"Raising young can be lethal for sea otters." *Science News*, SCIENCESHOT. Published online June 11, 2014 by Nadia Whitehead. http://news.sciencemag.org/biology/2014/06/raising-young-can-be-lethal-sea-otters

"Motherhood is no picnic for sea otter mums." *Inside JEB*, The Journal of Experimental Biology. Published online June 11, 2014 by Kathryn Knight. http://jeb.biologists.org/content/217/12/2029.2

"Where have all the otters gone? Decimated by the fur trade of the past centuries, the southern sea otter population has never fully recovered. UCSC scientists are piecing together the reasons why." *UCSC Magazine* Fall 2013. Published online Oct. 13, 2013 by Lily Dayton. http://news.ucsc.edu/2013/10/rev-fall-13-otters.html.

SELECTED SCIENTIFIC EXPEDITIONS AND FIELDWORK

Sarasota Dolphin Research Project (SDRP), Chicago Zoological Society - Sarasota, FL May 2015

As a postdoctoral researcher, I assisted in the annual field effort for the SDRP. Over a two-week period, we captured bottlenose dolphins and conducted health assessments in Sarasota Bay, Florida. More than 30 research projects were conducted concurrently. I participated as a field team member of Dr. Dan Costa's lab (UC Santa Cruz) providing logistical support and field assistance for bioenergetics studies.

USGS/UCSC Diablo Canyon Sea Otter Captures - San Luis Obispo & San Simeon, CA Oct 2012

As part of a collaborative field effort, I assisted in capturing, tagging, and instrumenting (VHF transmitters & TDRs) sea otters along the CA coast from San Luis Obispo to San Simeon. This was part of a 3-year monitoring project headed by the U.S. Geological Survey. Collaborating institutions included UC Santa Cruz, US Fish & Wildlife, Monterey Bay Aquarium, California Department of Fish & Wildlife, and UC Davis.

Weddell Seal Physiological & Behavioral Research - McMurdo Station, Antarctica Aug-Oct 2010

As PhD student, I participated in a collaborative field study in Antarctica examining the physiology, behavior, and energetics of Weddell seals. Our goal was to study the at sea foraging behavior and physiology of these animals as they foraged in complete darkness under the Ross Ice Shelf, Antarctica. This project was led by Dr. Terrie Williams (UC Santa Cruz), Dr. Randall Davis (Texas A&M University), and Dr. Lee Fuiman (University of Texas Austin). Funding and logistical support were provided by the National Science Foundation and the United States Antarctic Program (USAP).

USGS/UCSC Sea Otter Research Cruise - Big Sur, CA Nov 2008

As part of a collaborative field effort, I assisted in capturing, tagging, instrumenting (VHF transmitters & TDRs), and tracking sea otters off the coast of Big Sur, CA. This field effort was part of a 3 year monitoring program of southern sea otters off the central coast of California. This project was headed the U.S. Geological Survey and collaborating institutions included - UC Santa Cruz, Monterey Bay Aquarium, California Department of Fish and Wildlife, and UC Davis.

OTHER RELAVENT EXPERIENCE

Center for Ocean Solutions - Short Course on Ocean Policy - Monterey, CA Aug 2013

This course was co-taught by Meg Caldwell and Dr. Larry Crowder and hosted by the Center for Ocean Solutions and Stanford University. Space was limited and the application process was highly competitive. It introduced graduate students in the natural and social sciences to ocean policy and governance in the United States at national, regional, state, and local levels. We examined pressing issues in ocean sustainability from natural science, social science, and legal and policy perspectives, with an emphasis on the role of science in the policy and governance processes.

Lab Safety Representative – Williams Lab, UC Santa Cruz June 2011-April 2016

Responsibilities: Conduct regular safety inspections and ensure the lab meets all safety requirements.

Marine Mammal Physiology and Energetics Research Nov 2008-Present

I have been involved in a number of physiological and energetics focused research projects on a variety of marine mammal species over the duration of my career. The major data collection techniques for these projects have been open-flow respirometry, biochemical muscle tissue analyses, hematological analyses, accelerometer analyses, and behavioral examinations. Selected studies include: ontogeny of energetic demand in sea otters, metabolic demands of Weddell seals in the Antarctic winter, energetic cost of sound production in cetaceans, metabolic cost of swimming, diving, and molting in the Hawaiian monk seal, the energetic cost of gestation and lactation in sea otters, and quantifying the energetic demands of ice-dependent Arctic seals (ringed, bearded, and spotted).

Extensive Experience Conducting Marine Mammal Dissections July 2008-Present

I have conducted necropsys and dissections on a wide variety of marine mammal species, both for my own research and for educational purposes, throughout my career. Species I have worked with include: southern sea otter, harbor porpoise, bottlenose dolphin, northern elephant seal, northern fur seal, California sea lion, killer whale, humpback whale, and grey whale.

PUBLIC SERVICE ACTIVITIES & OUTREACH

Guest Polar Scientist Judge, Polar – ICE, Middle School Science Fair March 2018
California State University Monterey Bay, Monterey, CA

Public Science Talk – *Science on Tap*, UC Women in Science and Engineering July 2017
The Crepe Place, Santa Cruz, CA

Sea Otter Research Booth Volunteer - Coastal California NightLife Event Sept 2015
California Academy of Sciences, San Francisco, CA

Guest Speaker – Seymour Center Feb 2015
Docent Training Course, Santa Cruz, CA

USGS Sea Otter Outreach Presenter - 6th & 7th grade classes Nov & Dec 2014
Lakeview Middle School, Watsonville, CA.

Guest Speaker - UCSC Graduate Science Communication Program Oct 2014
Course: Reporting and Writing Science

Sea Otter Research Booth Volunteer May 2012
USGS Open House – Menlo Park, CA

Graduate School Panelist - UC Santa Cruz May 2011
Course: Biology Senior Thesis Course

Guest Speaker - Aptos High School May 2009
Class: Marine Biology

Guest Speaker - University of Portland March 2009
Course: Marine Biology of the Pacific Northwest

Science Fair Guest Judge April 2009
Santa Cruz Middle School, Santa Cruz, CA

Pacific Marine Mammal Center Volunteer - Laguna Beach, CA 2004-2008
Rescue and rehabilitation of marine mammals along the California coast.

USF SERVICE ACTIVITIES

Faculty Mentor, University Scholars Program
College Curriculum Committee
Biology Graduate Program Committee

Dr. M. Tim Tinker, Research Biologist
Curriculum Vitae
ttinker@nhydra.com, ttinker@ucsc.edu
http://werc.ucsc.edu/

Academic Record

University of California, Santa Cruz, CA
PhD Ecology and Evolutionary Biology, 1998-2004
Dissertation Research: Population biology and foraging behavior of the southern sea otter
University of Waterloo, Ontario, Canada
M.Sc., Biology, 1991-1993
Thesis: Behavioral ecology and energetics of grey seals (*Halichoerus grypus*) on land-fast ice
University of Guelph, Ontario, Canada
Honors B.Sc., Zoology, 1986-1990
Specialization: Wildlife Biology

Professional Appointments

- Adjunct Faculty, Department of Biology, Dalhousie University, Halifax NS, 2017- present
- Adjunct Faculty, Department of Geography, University of Victoria, Victoria BC, 2017- present
- Associate Adjunct Professor, UC Santa Cruz, Ecology and Evolutionary Biology, 2008 - present
- Research Scientist, US Geological Survey, Western Ecological Research Center, 2008 - 2017
- Assistant Research Biologist, UC Santa Cruz, Ecology and Evolutionary Biology, 2007-2008
- Post-doctoral researcher, UC Santa Cruz, Ecology and Evolutionary Biology, 2004-2007

Primary Publications

Chinn, SM, DH Monson, MT Tinker, MM Staedler, DE Crocker. (in press). Lactation and Resource Limitation Affect Stress Responses, Thyroid Hormones, Immune Function and Antioxidant Capacity of Sea Otters (*Enhydra lutris*). Ecology and Evolution.

Burgess, Tristan L., M. Tim Tinker, Melissa A. Miller, James L. Bodkin, Michael J. Murray, Justin A. Saarinen, Linda M. Nichol, Shawn Larson, Patricia A. Conrad, Christine K. Johnson. (in press). Defining the risk landscape in the context of pathogen pollution: *Toxoplasma gondii* in sea otters along the Pacific Rim. Royal Society Open Science

Gagne, Roderick; Tinker, M; Gustafson, Kyle; Ralls, Katherine; Larson, Shawn; Tarjan, L; Miller, Melissa; Ernest, Holly. 2018. Measures of effective population size in sea otters reveal special considerations for wide-ranging species. Evolutionary Applications, Early Ed. https://doi.org/10.1111/eva.12642

Silliman, Brian. R., Brent B. Hughes, Lindsay C. Gaskins, Qiang He, M. Tim Tinker, Andrew Read, James Nifong, John R. Stepp. 2018. Are the ghosts of nature past haunting conservation today? Current Biology 28(9): R532-R537

Nicholson, T. E., Mayer, K. A., Staedler, M. M., Fujii, J. A., Murray, M. J., Johnson, A. B., Tinker, M. T. and Van Houtan, K. S. 2018. Gaps in kelp cover may threaten the recovery of California sea otters. Ecography, doi:10.1111/ecog.03561

Kenner, M.C. and M.T. Tinker 2018. Stability and change in kelp forest habitats at San Nicolas Island. Western Naturalist. 78(4): 1-11

Hessing-Lewis, M., Rechsteiner, E.U., Hughes, B.B., Tinker, M.T., Monteith, Z., Olson, A., Henderson, M.M., Watson, J.C. 2017. Ecosystem features determine seagrass community response to sea otter foraging. Marine Pollution Bulletin. doi: 10.1016/j.marpolbul.2017.09.047.

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Watt, J.P., B.T. Krausse, M.T. Tinker. 1995. Bald Eagles kleptoparasitizing sea otters at Amchitka Island, Alaska. Condor 97(2): 588-590

Tinker, M.T., K.M. Kovacs, M.O. Hammill. 1995. Behavior and energetics of male gray seals (Halichoerus grypus) breeding on landfast ice. Behavioral Ecology & Sociobiology 36:159-170

Professional Activities

Research Positions:

- 2017-present: Research Ecologist, Nhydra Ecological, Halifax, Nova Scotia
- 2008- 2017: Principal Investigator, USGS Santa Cruz Field Station of the Western Ecological Research Center. Lead scientist in studies of sea otter population biology and near-shore ecology
- 2000-2007: Co-Principle Investigator for long-term, telemetry-based study of sea otter demography and foraging ecology in California. Supervisor: Dr. James Estes

Teaching Positions

Courses Taught:

- Quantitative Ecology (BioE 148): Upper level undergraduate/graduate course on quantitative methods of analysis and modeling in ecology. UC Santa Cruz, CA, Spring 2010, 2012, *2014, 2015*
- Readings in Ecology (BioE 293): Core Graduate Course in Ecology and Evolutionary Biology, UC Santa Cruz, CA, 2008
- Regular Guest Lectures for UCSC courses: Kelp forest Ecology, Ecology of Marine Mammals, Disease Ecology, Conservation Biology, Field Methods in Biology, Community Ecology

Graduate Students Advised

- Sarah Espinosa M.Sc. student, UCSC
- Sarah McKay-Strobel, Ph.D. student, UCSC

- Kat Dale, Ph.D. student, UCSC
- Lily Tarjan, Ph.D. graduate, UCSC
- Ben Weitzman, M.Sc. graduate, UCSC
- Jessica Fujii, M.Sc. graduate, UCSC
- Holly MacCormick, M.Sc. graduate, UCSC
- Michelle Staedler, M.Sc. graduate, UCSC
- Lillian Carswell, M.Sc. graduate, UCSC
- Gena Bentall, M.Sc. graduate, UCSC

Graduate Student Committee Memberships

- Rodrigo Beas, Ph.D. student, UCSC
- Robin Dunkin, Ph.D. student, UCSC
- Jason Hassrick, Ph.D. student, UCSC
- Kristen McCully, M.Sc. student, UCSC
- Kim Brewitt, Ph.D. student, UCSC
- Nicole Thometz, Ph.D. student, UCSC
- Justine Smith, PhD student, UCSC
- Joseph Stewart, PhD student, UCSC
- Mary Young, Ph.D. student, UCSC
- Chris Law, PhD student, UCSC
- Joshua Smith, PhD student, UCSC
- Zach Hoyt, Ph.D. student, UA-Juneau
- Nathan Stewart, Ph.D. student, UAF
- Jackie Lindsey, Masters Student, MLML
- Emily Golson, Masters Student, MLML
- Tristan Burgess, PhD Student, UC Davis
- Erin Rechsteiner, PhD student, U Victoria
- Wendel Raymond, Ph.D. student, UA-Juneau
- Ben Weitzman, PhD student, UAF
- Jessica Hale, PhD student, U. Washington
- Megan Moriarty, PhD Student, UC Davis
- Tracy Grimes, M.Sc. student, San Diego State University
- Zach Randell, Ph.D. student, OSU
- Taylor Gorham, Dalhousie university

Post Doctoral Students Advised or Co-Advised

- Dr. Mark Novak, UCSC, 2011-13
- Dr. Brent Hughes, UCSC, 2014-16

Workgroup and Committee Memberships:

- Invited panelist for international symposium and review of tool-use in non-human animals, convened by University of Oxford, UK, August, 2015
- Invited expert reviewer and participant in Marine Mammal Research Program Review by Canadian Department of Fisheries and Oceans, Ottawa, Ontario, Canada, October 2014
- Invited expert panelist on Alaska Sea Grant and University of Alaska Fairbanks sponsored outreach forum to Alaskan communities to discuss sea otter – human interactions. Juneau, Alaska, May, 2014
- Invited expert panelist and participant in Canadian workshop to review ecological and social impacts of sea otter recovery, sponsored by Pew Fellowships. British Columbia, Canada, June 2014.
- Invited expert panelist for US Fish and Wildlife Service and University of Alaska Fairbanks Symposium on southeast Alaska sea otter recovery, Juneau, Alaska, February, 2013
- Invited expert witness for the black abalone recovery team (NMFS), August 2013
- Invited expert witness for hearings convened by the Federal Marine Mammal Commission (June 2013)
- Member of Southwest Alaska Sea Otter Recovery Team (SWAKSORT) convened by US FWS
- Invited participant, Marine Mammal Commission symposium to advise on the use of population viability analysis in marine mammal populations. Savannah, GA, Sept 2005 (report requested by US Congress)
- Invited participant, Marine Mammal Commission symposium to determine the ecological role of killer whales in the north Pacific. Seattle, WA, Apr. 2005 (report requested by US Congress)
- Invited participant, US Fish and Wildlife Service workshop to develop long-term monitoring plan for sea otters in south-west Alaska. Anchorage, AK, Feb. 2005.
- Invited participant, Alaska Sea Life Center/US Fish and Wildlife Service symposium to determine research priorities for the sea otter in south-west Alaska. Seward, AK, Apr. 2004.
- Invited participant, US Fish and Wildlife Service workshop to study sea otter decline in south-west Alaska. Anchorage, AK, Apr. 2002.
- Invited participant, National Center for Ecological Analysis and Synthesis working group on Ecosystem Based Management: Investigating the Roles of Top Predators, 2004-2007

Professional Society Memberships:

- Member of The Society for Marine Mammalogy, 1991-present
- Member of the Ecological Society of America, 2005-present

Journal Reviews and Editing

- Subject Editor, Ecological Applications (Nov 2013)
- Manuscript Reviews provided regularly (5-15 per year) for the following journals:
    - The American Naturalist
    - Ecology
    - Ecological Applications
    - Marine Mammal Science
    - Proceedings of the Royal Society
    - Journal of Animal Ecology
    - Can. J. Fisheries and Aquatic Science
    - Journal of Wildlife Management
    - Trends in Ecology and Evolution
    - Marine Biology
    - Oecologia
    - Animal Behavior
    - Population Ecology
    - Oikos
    - Marine Ecology Progress Series
    - Behavioral Ecology
    - Journal of Sea Research
    - Ecograophy
    - PLOS One
    - Proceedings of the National Academy of Science (PNAS)

Special Certifications and continued Professional Training:

- Completed Bayesian Statistics workshop, USGS-WERC, 2010: Bayesian inference for environmental scientists, ecologists and wildlife biologists
- Certified DOI Motorboat Operator (MOCC)
- First Aid/CPR certified (current) and trained in Wilderness First Aid

Grants, Awards and Scholarships

- National Science Foundation, 'Kelp forest community resilience in action' (co-PI, 2015-2018)
- Aleutian Bering Sea Islands LCC, 'Assessing effects of climate change and ocean acidification on sea urchin productivity and trophic interactions in the Aleutian Islands: Consequences for sea otter recovery' (PI, 2015-2016)
- US Navy, 'Sub-tidal Community Monitoring, San Nicolas Island' (PI, 2014-2015)
- US Fish and Wildlife Service, 'Aleutian Sea Otter Hot Spot Analysis' (PI, 2014-2014)
- California Coastal Conservancy, 'Sea Otter Habitat Use and Biology in Elkhorn Slough' (PI, 2013-2016)
- Oiled Wildlife Care Network, 'Developing a Network-based Tag for Sea Otter Monitoring' (PI, 2013-2016)
- US Fish and Wildlife Service, 'Sea Otter Ecology in Elkhorn Slough' (PI, 2013-2015)
- US Fish and Wildlife Service, 'Sea Otter Movements and Habitat Use' (PI, 2013-2014)
- US Fish and Wildlife Service, 'Sea Otter Population Analysis, SE Alaska' (PI, 2013-2014)
- Pacific Gas and Electric, 'Effects on Sea Otters of Seismic Surveys and Other Stressors' (PI, 2012-2014)
- US Fish and Wildlife Service, 'Modeling Sea Otter Range Expansion' (PI, 2012-2013)
- California Coastal Conservancy, 'Effect of Sea Otter Stressors, Big Sur and Monterey comparison ' (PI, 2011-2013)
- Department of Interior, 'Coastal Ecosystem Responses to Stressors from Land and Sea' (co-PI, 2010-2015)
- Bureau of Ocean Energy Management , 'Sea Otter Range Expansion in Southern California' (PI, 2010-2014)
- UC Davis/NSF, 'transmission dynamics of Toxoplasma gondii at the land-sea Interface ' (co-PI, 2010-2013)
- Alaska Sea Life Center, 'Report on Commander Island sea otter survey' (PI, 2010-2010)
- US Fish and Wildlife Service, 'Sea Otter Population Viability Analysis' (PI, 2009-2010)
- US Fish and Wildlife Service, 'Stressors Affecting Sea Otter Populations' (PI, 2008-2010)
- NPRB, 'NPRB Project 717, Causes of sea otter decline in SW Alaska' (co-PI, 2007-2010)
- UCSB MMS Coastal Marine Institute, 'Population Biology of Sea Otters at the South of their Range' (co-PI, 2000-2003)

- Research Grant from Friends of the Sea Otter: Development of a Spatially Explicit Population Model for the Southern Sea Otter, 2000
- Departmental Graduate Fellowship, Ecology and Evolutionary Biology Dept., UC Santa Cruz, 1998

Professional Technical Reports:

Tinker, M. T. et al., 2018. Sea otter monitoring plan for Gwaii Haanas National Park Reserve, National Marine Conservation Area Reserve and Haida Heritage Site. Final report for Parks Canada.

Tinker, M. T. et al., 2015. “Sea Otter Range Expansion and Habitat Use in the Santa Barbara Channel.” Draft Final Report to the Bureau of Ocean Energy Management. US Geological Survey Project Report, 88 pages

Tinker, M. T., et al., 2013. “Sea Otter Population Biology at Big Sur and Monterey California: Investigating the Consequences of Resource Abundance and Anthropogenic Stressors for Sea Otter Recovery”. Final Report to California Coastal Conservancy and U.S. Fish and Wildlife Service. US Geological Survey Project Report. 242 pages

Laird Henkel, Michael D Harris, Jack Ames, R Glenn Ford, Michelle Staedler, M Tim Tinker. 2014. Use of Decoys to Assess Effectiveness of Aerial Surveys for Sea Otters. California Department of Fish and Wildlife Office of Spill Prevention and Response Technical Report 14-2

Miller, M.A., Oates, S.C., Dodd, E,, Johnson, C.K., Tinker, M.T. 2014. Risk Factors for Shark Bite Mortality in Southern Sea Otters. Final Report for California Coastal Conservancy Agreement No. 20129034

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Estes, J.A., J.L. Bodkin and M.T. Tinker. 2010. “Threatened southwest Alaska sea otter stock: delineating the causes and constraints to recovery of a keystone predator in the North Pacific Ocean”. NPRB Project 717 Final Report

Tinker, M. T., J. L. Bodkin, J. A. Estes, K. Ralls. 2009. Appendix B: Population Viability Analysis for the southwest Alaska sea otter. In USFWS (2009). Southwest Alaska Distinct Population Segment of the Northern Sea Otter (Enhydra lutris kenyoni), Draft Recovery Plan. Marine Mammals Management Office, US Fish and Wildlife Service.

Oftedal, O., K. Ralls, M.T. Tinker and A. Green. 2007. Nutritional constraints on the southern sea otter in the Monterey Bay National Marine Sanctuary, and a comparison to sea otter populations at San Nicolas Island, California and Glacier Bay, Alaska. Final Report to the Monterey Bay National Marine Sanctuary and the Marine Mammal Commission.

Tinker, M. T., J. A. Estes, K. Ralls, T. M. Williams, D. Jessup, and D. P. Costa. 2006. Population Dynamics and Biology of the California Sea Otter (Enhydra lutris nereis) at the Southern End of its Range. MMS OCS Study DRAFT REPORT. Page 351. MMS Cooperative Agreement Number 14-35-0001-31063. Coastal Research Center, Marine Science Institute, University of California, Santa Barbara, California.

GB Bentall, MT Tinker. 2006. The effect of the Moss Landing Power Plant thermal discharge plume on sea otter behavior and distribution. Report submitted to the Monterey Bay National Marine Sanctuary Integrated Monitoring Network (SIMoN) and Monterey Bay Sanctuary Foundation

Tinker, M.T., Estes, J.A., Doak, D.F. 2000. Development of a spatially explicit population model to assess potential population impacts associated with translocation of sea otters from south of Pt. Conception. Final report to Friends of the Sea Otter, October, 2000. Monterey, California.

Estes, J.A., Konar, B., Tinker, M.T. 1998. Sea Otter Population Biology and Subtidal Community Ecology at Shemya Island, Alaska. Final Report for Department of Defense Legacy Project Number 9401280 & 9510014

Tinker, M.T., Estes, J.A. 1997. Summary Report on Sea Otter Captures for Blood Contaminant Analysis and Collection of Population Data in the Western Aleutian Islands, 1997. Summary Report to the Navy, U.C. Santa Cruz, CA.

Tinker, M.T., Heaven, P.C., Ingham, L. 1997. Columbia Basin, Large Mammal Monitoring: 1994-97 Aerial Surveys, Final Report. Columbia Basin Fish and Wildlife Compensation Program, Technical Report

Tinker, M.T., Estes, J.A. 1996. The population ecology of sea otters at Adak Island, Alaska. Final Report to the Navy, Contract # N68711-94-LT-4026, U.C. Santa Cruz, CA.

Selected Talks and Presentations at Professional Meetings

Tinker. M. T. "Confessions of a Keystone Carnivore: complexity in food web interactions". Invited Seminar Speaker, Dalhousie University, Oct 2017 [Invited]

Tinker, M.T. “An Old Dog learns New Tricks from a Big Weasel: 25 Years of Sea Otter Research” Invited Keynote Speaker, Sea otter awareness week 2017, Seymour Center, Santa Cruz. Sept 2017.

Tinker. M. T. “Tool Use in Sea Otters” Presentation and Panel Participant, American Archaeology Society Annual International Conference, Vancouver, British Columbia, March 2017 [Invited panelist]

Tinker. M. T. "Confessions of a Keystone Carnivore: when simple trophic cascades go sideways ". Invited Seminar Speaker, Scripps Institute of Technology, Nov 2017 [Invited]

Tinker. M. T. "Complex food web interactions and diverse ecosystem effects of sea otters". Invited Seminar Speaker, Haida Fisheries Conference, Haida Gwaii, British Columbia, March 2016. [presentation] [Invited]

Tinker. M. T. "Sea Otter Ecosystem Function in alternative habitats". Invited Seminar Speaker, Moss Landing Marine Labs, California, April 2015. [presentation] [Invited]

Tinker. M. T. "Growth and Equilibrium in Sea Otters Re-visited: a new paradigm for sea otter conservation". Invited Plenary Presentation to Friends of the Sea Otter Special Event, Big Sur, CA, Sept 2015. [presentation] [Invited]

Tinker, MT, L Carswell, B Hughes, J Tomoleoni, B Weitzman, B Hatfield, J Estes, J Bodkin, K Ralls, L Bowen, K Miles, M Kenner, M Staedler, M Murray, A Johnson, B Kelly, S Espinosa, J Fujii, T Nicholson, K Mayer, M Miller, L Henkel, D Jessup, M Harris, J Ames, C Young, F Batac, E Dodd, T Burgess, C Johnson, P Conrad, K Shapiro, F Gulland, N Thometz, N LaRoche, L Tarjan, G Bentall, E Golson, S Newsome. 2015. Between a rock (crab) and a sharp place: the curious conundrum of the southern sea otter, and some unexpected silver linings. 21st Biennial Conference of the Biology of Marine Mammals: Bridging the Past to the Future, San Francisco, CA. 13-18 December 2015. [presentation] [Abstract]

Tinker, MT, B Hatfield, M Harris, J Ames. 2015. Exponential increase in rate of white shark attacks on sea otters in central California: demographic consequences and possible causes. 2015 American Fisheries Society Meeting, Santa Cruz, CA. 9 April 2015 [presentation] [Abstract] [Invited]

Tinker, M.T., Hughes, B. November 2014. Oral Presentation. From kelp forests to pickle weed: sea otter effects on ecosystem dynamics in two distinct coastal habitats. Invited Presented to the staff for Monterey Bay Aquarium's Conservation Science Seminar Series. [presentation] [Invited]

Tinker, M.T., J.A. Estes and J. L. Bodkin. 2013. "Effects of landscape and limited mobility on sea otter population recovery". Society for Marine Mammalogy, 20th Biennial Conference on the Biology of Marine Mammals, Dunedin, New Zealand. [presentation] [Abstract]

Tinker, M.T. and Novak, M. 2013. "Effects of time-averaged sampling on the inferred strength and temporal consistency of intraspecific diet specialization.". Invited speaker at Special Symposium : "Intra-population Niche Variation: From Incidence to Relevance ", 98th Annual Meeting of the Ecological Society of America, Minneapolis, MN, August 2013. [presentation] [Abstract] [Invited]

Tinker, M.T. 2013. "The sea otters of central California: keystone predators and indicators of near-shore ecosystem influences". Invited plenary speaker at "NRS day 2013: a celebration of the UC Nature Reserve System", Bren School of Environment, UC Santa Barbara, Feb 2013. [presentation] [Invited]

Tinker, M.T. 2013. "A paradigm coming of age? The promises, pitfalls and ontology of the Top-down system of thought in ecology". Invited plenary speaker for Presidential Symposium, Western Society of Naturalists Annual Meeting, Oxnard, CA, November 2013. [presentation] [Abstract] [Invited]

Tinker, MT, B Hatfield, M Harris, J Ames. 2013. Exponential increase in rate of white shark attacks on sea otters in central California: demographic consequences and possible causes. Sea Otter Conservation Workshop. March, 2013, Seattle, WA. [presentation] [Abstract]

Tinker, MT, B Hatfield, M Harris, J Ames. 2012. When the Shark Bites: Implications of Increasing White Shark Attacks for Southern Sea Otters. Southern Sea Otter Research Update Meeting. Feb 2013. Santa Cruz, California. [presentation] [Abstract]

Tinker, M.T., J.L. Bodkin, M. Staedler, D.H. Monson, B. Ballachey, K. Kloecker, G. Esslinger, H. Coletti, G. Bentall, J. Estes, O.T. Oftedal, K. Ralls, J. Tomoleoni, N. LaRoche, B. Weitzman, and J. Perry, 2011, Sea otter foraging ecology and energetics across populations. Sea Otter Conservation Workshop VII, March 2011, Seattle, WA. [presentation] [Abstract]

Tinker, M.T., Hatfield, B.B., Harris, M.D. and Ames, J.A.. 2011. "Increasing mortality from white shark attacks drives decline in southern sea otters: estimating demographic impacts using a spatially structured projection model". Society for Marine Mammalogy, 19th Biennial Conference on the Biology of Marine Mammals, Tampa, Florida. [presentation] [Abstract]

Tinker, M.T., Guimarães, P.R., Novak, M. 2011. "The structure and mechanisms of intraspecific diet polymorphisms". Invited speaker at Special Symposium "The Ecological Consequences of Intraspecific Variation ", 96th Annual Meeting of the Ecological Society of America, Austin, Texas, August 2011. [presentation] [Abstract] [Invited]

Tinker, M.T., and Novak, M. 2011. "Measuring temporal consistency of intraspecific diet specialization.". Invited speaker at special symposium, "Individuality in Marine Mammals. Society for Marine Mammalogy, 19th Biennial Conference on the Biology of Marine Mammals, Tampa, Florida.[presentation] [Abstract] [Invited]

Tinker, M.T. 2011. "Diets and Energetics Across Sea Otter Populations". 7th Annual International Workshop on Sea Otter Conservation, Seattle, WA. [presentation] [Abstract]

Tinker. M. T. "Causes and Sonsequences of Diet Specialization in Sea Otters". Invited Seminar Speaker, Moss Landing Marine Labs, California, May 2010. [presentation] [Invited]

Tinker. M. T. "Diet Specialization and Disease Exposure in Sea Otters". Invited Seminar Speaker, UC Davis Wildlife Epidemiology Class, California, February, 2010. [presentation] [Invited]

Tinker, M.T., J. Bodkin, M. Staedler, D. Monson, and G. Bentall, 2009, Using archival time-depth recorders to measure within- and between-population variation in diet and foraging success of sea otters. Carnivores Conference, Nov. 2009, Denver, CO. [presentation] [Abstract]

Tinker, M.T., Guimarães, P.R., Novak, M., Staedler, M.M., Bentall, G.B., Bodkin, J.L., Estes, J.A. Oct. 2009. Using network analysis to assess individual patterns of resource use: sea otters exhibit modularity at high density sites, providing evidence for a facultative diet polymorphism. Marine Mammal Society International Biannual Conference. Oct. 2009, Quebec City, Canada. [presentation] [Abstract]

Tinker, M.T., D. Monson, G. Esslinger, M. Staedler, J.L. Bodkin, 2009, Inferring reproductive and survival events from TDR data. Sea Otter Conservation Workshop VI, March 2009, Seattle, WA. [presentation] [Abstract]

Tinker, M.T., Christine Kreuder-Johnson, Melissa Miller, Dave Jessup, Jonna Mazet, Daphne Carlson Bremer,, Pat Conrad, James Estes. 2009. "Diet, density, disease and death in sea otters: implications for conservation and management." Carnivore Conference: Carnivore Conservation in a Changing World, Nov 2009, Denver, CO. [presentation] [Abstract]

Tinker, M.T., Bodkin, J., Staedler, M.M., Esslinger, G., Monson, D.H. May 2009 "Using core temperature records from biologging records to detect reproductive events." International sea otter conservation workshop, Seattle, WA. [presentation] [Abstract]

Tinker, M.T. Sept. 2009. Density-dependent diet diversification and individual differences in foraging behavior determine risk of disease exposure in southern sea otters. Society for Conservation Biology, Flagstaff, AZ. [presentation] [Abstract]

Tinker, M.T. Jan 2009. Using long term research on sea otters and kelp forest food webs to study the effects of climate change on coastal ecosystems. USGS/USFWS COASTAL CLIMATE CHANGE CONFERENCE FOR CALIFORNIA, OREGON AND WASHINGTON. San Francisco, CA. [presentation] [Abstract]

Tinker, MT. 2008. "Sea otter diets & population status: causes and consequences of individual foraging specializations" Invited Speaker at UC Santa Cruz EE Biology Seminar Series, June 2008: [presentation] [Invited]

Tinker, M.T., J. Bodkin, M. Staedler., G. Esslinger, D. Monson, G. Bentall, and M. Murray, 2008, Using TDR records to detect reproductive events in sea otters. International Biologging Conference, Sept. 2008, Pacific Grove, CA. [presentation] [Abstract]

Tinker, MT. 2007. "Sea otter diets & population status: causes and consequences of individual foraging specializations". Invited Speaker at Bodega Marine Laboratories Seminar Series, Jan 2007 [presentation] [Invited]

Tinker, M.T., G. Bentall, A. Burdin, and J.A. Estes. 2007. Ecological and behavioral responses to K: sea otters and kelp forest ecosystems in the Aleutian and Commander islands. 17th Biennial Conference on the Biology of Marine Mammals, Cape Town, South Africa. [presentation] [Abstract]

Tinker, M.T., C. Kreuder-Johnson, P. Conrad, M. Staedler, D. Jessup, J. Estes, M. Miller and J. Mazet. 2007. Linking Individual Behavior and Population Health: Tracking Protozoal Pathogen Exposure in Southern Sea Otters. 5th Workshop on Sea Otter Conservation, Seattle, WA. [presentation] [Abstract]

Tinker, M.T., C. Kreuder-Johnson. 2006. Linking Individual Behavior and population health: a multidisciplinary approach to predicting risk of disease exposure in sea otters. 20th Annual Meeting of the Society for Conservation Biology, San Jose, CA. [presentation] [Abstract]

Tinker, M.T., J.A. Estes, M.M. Staedler, J.L. Bodkin. 2005. Alternative diet specializations in the southern sea otter: energetic implications of a behaviorally-mediated foraging polymorphism. 16th Biennial Conference on the Biology of Marine Mammals, San Diego, CA. [presentation] [Abstract]

Tinker, M.T., D.P. Costa, J.A. Estes, N. Wieringa. 2005. Individual dietary specialization and dive behavior in the California sea otter: using archival time-depth data to detect alternative foraging strategies. 2nd International Bio-logging Science Symposium, St. Andrews, Scotland. [presentation] [Abstract]

Tinker, M.T., D.F. Doak, J.A. Estes. 2005. Effect of demographic variation and dispersal patterns at multiple spatial scales on the population recovery and range expansion of a threatened carnivore. 90th Annual Meeting of the Ecological Society of America, Montreal, Canada. [presentation] [Abstract]

Tinker, M.T., J.A. Estes, J.L. Bodkin, M.M. Staedler, and D.H. Monson, 2004, Studying sea otter foraging ecology: a review of some methodological approaches. Alaska sea otter research priorities workshop: Addressing the decline of the southwest Alaska sea otter population. April 2004, Seward, AK. [presentation] [Invited]

Tinker, M.T., Estes, J.A., Yeates, L., Staedler, M.M. 2002. Studying Sea otter Foraging Ecology. California and the World Ocean '02, Santa Barbara, CA [poster] [Abstract]

Tinker, M.T., Estes, J.A., Staedler, M.M., Bodkin, J. 2002. Sea otter Foraging Ecology: Sources of Variation in Dive Behavior, Diet and Foraging Success. Carnivores 2002 - From the Mountains to the Sea: A Conference on Carnivore Biology and Conservation, Monterey, CA. [presentation] [Abstract]

Tinker, M.T., Estes, J.A., Doak, D.F. 2000. A Model of Southern Sea Otter Population Dynamics and Range Expansion. Seventh Joint US-Russia Sea Otter Workshop, Monterey, California. [presentation] [Abstract]

Tinker, M.T., Doak, D.F. 2002. Southern Sea Otter Demography and Population Analyses. Carnivores 2002 From the Mountains to the Sea: A Conference on Carnivore Biology & Conservation, Monterey, CA. [presentation] [Abstract]

Tinker, M.T., Estes, J.A., Mangel, M. 2001. Individual variation in diet and feeding behavior of sea otters: cultural transmission of foraging skills contributes to the persistence of alternative foraging specializations. Invited Presentation at the Workshop on Culture in Marine Mammals, Fourteenth Biennial Conference on the Biology of Marine Mammals, Vancouver, British Columbia. [presentation] [Abstract]

Tinker, M.T., J.A. Estes, J.P. Watt, and D.H. Monson, 1999, A comparison of indices used to assess sea otter population status: scats may be worth a closer look. Biennial Conference, Biology of Marine Mammals, XIII, Wailea, HI. [presentation] [Abstract]

Tinker, M.T., Estes, J.A. 1997. Sea otter population decline in the western Aleutian Islands: an overview of trends, effects and possible causes. Sixth Joint US-Russia Sea Otter Workshop, Forks, Washington. [presentation] [Abstract]

Tinker, M.T., Estes, J.A. 1997. Is food-limitation causing the sea otter population decline at Adak Island, Alaska? Contrary evidence from activity budgets, diet and prey Size. Twelfth Biennial Conference on the Biology of Marine Mammals, Monaco. [presentation] [Abstract]

Tinker, M.T., Estes, J.A., Meehan, J. 1996. Demography, behavior and diet of sea otters at Adak Naval Reservation, Alaska. The Wildlife Society Third Annual Conference, Cincinnati, Ohio. [presentation] [Abstract]

Tinker, M.T., Kovacs, K.M., Hammill, M.O. 1993. Reproductive behavioral tactics of male grey seals breeding on landfast ice. Tenth Biennial Conference on the Biology of Marine Mammals, Galvaston, Texas. [presentation] [Abstract]

Curriculum Vitae

RAYMUND F. WACK M.S., D.V.M., Dipl. ACZM

A. Senior Veterinarian – Wildlife Health Center
School of Veterinary Medicine
University of California – Davis
1 Shields Avenue
Davis CA 95616-8747

Director of Veterinary Services
Sacramento Zoo
3930 West Land Park Dr
Sacramento CA 95822-1123
916-808-8808

B. Address [redacted]

Phone 707-399-9350

E-mail rfwack@ucdavis.edu

C. Personal Information
Available upon request

D. Education

Date	Institution	Degree
1991	Ohio State University Veterinary Clinical Sciences Thesis: Response of Cheetahs to Routine Vaccination	Master of Science
1991	Ohio State University	Residency in Zoo Medicine
1987	Ohio State University	Doctor of Veterinary Medicine
1985	Ohio State University *Cum Laude* with Honors in the Liberal Arts with Distinction in Zoology.	Bachelor of Science

Educational Awards –
2018 UCDavis SVM Faculty Clinical Excellence Award
2010 Sacramento Zoo Summer Camp Teacher of the Week
1990 Telinject Graduate Research Award
1987 Raptor Rehabilitation Excellence Award
1986 Solvay Veterinary Student Award
1985 Phi Beta Kappa

E. Specialty Board Certification & Licenses

2017 Diplomat – European College of Zoological Medicine – Zoo Health Maintenance Specialty
1997 Diplomat - American College of Zoological Medicine - Zoo Medicine Specialty
State Veterinary Licenses: California, Ohio
DEA license, DEA Narcotics license (including ultra-potent narcotics)
USDA Accreditation

Training Activities
Senior Leadership Training Program – Empowering Performance Inc (2016-2017 Sacramento Zoo)

Amphibian Biology and Management – Professional Training Program AZA (2008)
24 hour Hazardous Waste Operations and Emergency Response (HAZWOPER) certification current

F. Professional Positions

Dates	Position/Title	Institution
Jan 2003 – present	Conservation Committee Chair	Sacramento Zoo
May 2001 – present	Chief of Service Zoo Medicine	UC Davis VMTH
Aug 2000 – present	Coordinator Zoo Med Residency	UC Davis/San Diego Zoo
Aug 2000 – present	Senior Veterinarian	UC Davis School of Vet Med
Aug 2000 – present	Director of Veterinary Services	Sacramento Zoo
May 1996 – Aug 2000	Director of Animal Health	Columbus Zoological Gardens
July 1991 – Aug 2000	Adjunct Associate Professor	Ohio State University
July 1991 - May 1996	Associate Veterinarian	Columbus Zoological Gardens
July 1988 - July 1991	Resident Zoo Medicine	Columbus Zoo & Ohio State Univ.
July 1987 - July 1988	Associate Veterinarian	Animal Clinic Northview

G. Teaching Experience

UCD VME 435C Zoological Medicine Block – SP semester 10 week course – 3 week subblock leader and lecturer 2017, Course coordinator 2014 – 2016. This intensive course immerses students in all aspects of zoological medicine by integrating classroom lectures, field trips, wet labs and student presentations. Course encompasses approximately 350 contact hours over the 10 week period. In addition to course coordination, I am primary instructor for 3 weeks of the 10 weeks and present approximately 15 hours of lecture plus lead 4 wetlabs/field trips. Evaluations are available.

UCD VMD Senior Clinics. Student enrollment 30- 40 students, student evaluations available. 2001 - present. As service chief for Zoological Medicine and staff veterinarian for the Sacramento Zoo, I teach senior veterinary students on the Zoo Med clinics rotation as well as instruct the first year zoo med resident. I am the program coordinator for the zoo med residency.

UCD Nutrition 115 –Animal Feeds and Nutrition Wi Qtr 4 units, 2009- present. Student enrollment 120. I teach a two hour lecture on Zoo and Wild Animal Nutrition for this Animal Science undergraduate class.

VME 493-042 Zoological Medicine Journal Seminar coordinator. I lead 1 hour weekly journal club for faculty and residents interested in Zoological Medicine. 2000 – present. Average 10 participants per week. Seminar is teleconferenced to San Diego Zoo and to former residents studying for ACZM boards.

VME 493-013 Avian Medicine Journal Seminar – Resident mentor – participate in weekly 1 hour journal club for faculty and residents interested in Zoological Companion Animal medicine. 2000 – present. Average 6 participants per week.

PMI 481R-001 Zoological Species Pathology Seminar – 2004 – present. Participant in twice monthly hourly seminar on pathology of zoological species based upon pathology materials submitted through the UCD VMTH Pathology Service. Average 16 participants across departments and campus units.

VSR 410R Zoological Species Radiology Seminar – Co-course coordinator. Monthly 1.5 hour seminar presenting imaging cases of zoological species. 2003 – present. Averages 8 participants including Radiology residents and faculty, CAPE residents and faculty, Zoo Med Residents and faculty, Primate Center Residents and faculty, northern California Zoological Institutions and UC system lab animal veterinarians.

UCD VME 410 Management of Captive Animals Sp Qt 2 units Course coordinator 2007- 2015

Lecturer 2004-2002 Student enrollment 20 – 60 students, student evaluations available. I taught 8 lectures in the course as well as coordinating the course.

UCD VME 415 Diseases of Captive Wildlife Fall Qt 2 units Course Coordinator 2005-2015 Student enrollment 20 – 50. Student evaluations available. I taught 6 lectures in the course as well as course coordination.

UCD VME 487 Comparative Anatomy and Physiology of Non-domestic Animals
Winter Qtr. Lecturer 2001- 2011. Course coordinator 2012 – 2015. Student enrollment 20 -60 students. Student evaluations available. I taught 5 lectures.

UCD VME 419 Companion and Exotic Small Animal Medicine and Surgery Fall Qtr 3.4 units 2003-2015. Student enrollment 20 – 80 students, student evaluations available. I taught 6 – 8 hours of lectures on reptile medicine and surgery.

PMI 418 Health and Disease in Terrestrial Wildlife WI Quarter. I taught a 2 hour lecture in Ecosystem Health Issues affecting Reptiles and Amphibians. 2008- 2015. 20 – 40 students. Evaluations available.

UCD PMI 419 Field Techniques for Assessment of Wildlife and Ecosystem Health Sp Qtr 2 units. Student enrollment 10 – 20 students. 2004 - 2012. My teaching involvement alternated between 8 hours on one day and 40 hours (5 days) of camping with the class in Southern California.

UCD VMD 490 Hospital techniques Wi Qtr 2003, 2002, 2001. Student enrollment 40 – 100. I organized and taught the reptile handling section of the lab (3 hours repeated 10 times during the quarter.

H. Audiovisual/Autotutorial Materials Developed

2016 Conservation Efforts and Impacts – Sacramento Zoo
2016 Acronyms and Abbreviations in Zoological Medicine
2016 Anesthetic Drugs and Combinations in Wildlife Medicine
2016 Medicine and Husbandry of Great Apes
2015 Clinical Pharmacology in Zoological Medicine
2015 Medicine and Husbandry of Prosimians and New World Primates
2015 Darting Equipment and Anesthesia Monitoring in Zoo and Wildlife Medicine
2015 Amphibian Medicine and Husbandry
2014 Introduction to Primate Medicine
2014 Animal Rights and Animal Welfare in Zoological Medicine
2014 Restraint and Handling Techniques in Zoological Medicine
2014 Clinical Pathology in Zoological Medicine
2014 Wildlife laws and Regulations
2013 Husbandry and Medicine of Bats
2010 Overview of Zoo Management Strategies
2010 Overview of Dentistry in Zoos
2008 Reptile and Amphibian Ecosystem diseases
2007 Preventative Medicine Programs in Zoos
2006 Diseases of Free-Ranging Reptiles and Amphibians
2005 Management and Husbandry of Fish
2005 Diseases of Felidae
2004 Diseases of Chiroptera
2004 Ethics in Zoos and wildlife
2004 The roles of Zoo and Wildlife Veterinarians
2004 Reptile Anatomy, Physiology and Husbandry
2004 Amphibian Anatomy, Physiology and Husbandry
2003 Diseases of Cheetahs
2003 Zoonotic Diseases of Captive Wildlife and Employee Health
2003 Diseases of Marine Mammals - Cetacea
2002 Diseases of Zoo Birds

2002 Diseases of Small Primates
2000 Pemphigus Foliaceus in a Hedgehog
2000 FIV in Captive Lions
2000 Management and Preventative Medicine in Cheetahs
2000 Infectious Diseases of Cheetahs
1999 Introduction to Ultrasound in Exotic Animals
1999 Interpretation of Clinical Pathology Data in Carnivores
1995 Water Quality Testing for Practitioners
1995 Internet Resources for Wildlife Vets - Multimedia
1995 Gill Function and Parasites of Freshwater Fish
1994 Amphibians - VME 608 core course
1994 Zoo Animal Case Studies
1992 Reptile Anesthesia and Chemotherapeutics
1992 Reptile Reproduction
1992 Diseases of Lizards, Turtles and Crocodiles
1991 Diseases of Amphibians & Reptiles
1991 Diseases of Native American Wildlife
1991 Diseases of Marine Mammals
1991 Avian Parasitology

I. Research Support

2018
Grant name: Phil and Karen Drayer Wildlife Health Center Fellowship Award
Project title: Pharmacokinetics of single-dose subcutaneous voriconazole in healthy Western pond turtles (Actinemys marmorata)
Investigators: Louden Wright, Jenessa Gjeltema, Ray Wack, Lisa Tell
Date: February 15, 2018- February 14, 2019
Amount of grant [redacted]
Funder: University of California Davis Wildlife Health Center

Project title: Pharmacokinetics of single-dose subcutaneous voriconazole in healthy Western pond turtles (Actinemys marmorata)
Investigators: Louden Wright, Jenessa Gjeltema, Ray Wack, Lisa Tell
Date: February 15, 2018- February 14, 2019
Amount of grant: [redacted]0
Funder: Sacramento Zoo Conservation Fund

Grant name: Stoneybrook Farms/AZA Grant
Project title: Pharmacokinetics of single and multiple dose subcutaneous voriconazole in healthy Western pond turtles (Actinemys marmorata)
Investigators: Louden Wright, Jenessa Gjeltema, Ray Wack, Lisa Tell
Date: February 2018- February 2019
Amount of grant: [redacted]
Funder: Stoneybrook Farms

Grant name: Headstarting Giant Garter Snakes in the Natomas Basin
Investigators: Allie Essert, Brian Halstead, Ray Wack
Date: May 2018 – Dec 2018
Amount of grant: [redacted]
Funder: USGS New Dixon Station

2016
Evaluation of Blood Lactate Clearance in Live-Stranded Pinnipeds. Matt Marinkovich DVM, Ray F. Wack, DVM, Jenessa Gjeltema DVM, Cara Field DVM

Karen C Drayer Wildlife Health Center Fellowship Grant $4,993
Sacramento Zoo Conservation Fund Grant [redacted]

Assessing Temporal and Spatial Variation in the Fecundity and Health of Female Giant Garter Snakes (Thamnophis gigas) in response to Water Availability in the Sacramento Valley a six year survey. SPO Project Number 201700793. Ray F. Wack
USGS-CESU Grant Program $1[redacted]

2015
Detection of avian bornavirus in captive thick-billed parrots (*Rhynchopsitta pachyrhycha*) by RT-PCR and ELISA. Mary Thurber DVM, Ray F. Wack DVM, Nadine Lamberski DVM, Jenessa Gjeltema DVM
San Diego Zoo Collection Health Research Initiation Fund Grant $8,020
Sacramento Zoo Conservation Fund Grant $[redacted]

Health survey and special ecology of Giant Garter Snakes in northern California. Ray F Wack, Brian Halstead
USGS University grants G15PX01336 [redacted]

2014
Comparison of 0.9% Saline and Amphibian Ringer's Immersions on Hematology and Plasma Chemistry Values in California Tiger Salamanders (*Ambystoma californiense*). Sean Brady DVM, Anne Burgdorf DVM, Ray F. Wack DVM.
Sacramento Zoo Conservation Fund Grant $[redacted]

Radio telemetry and health survey studies in the Giant Garter Snake. Ray F Wack, DVM, Eric Hansen.
USBR Water Conservation Grant $6,760

2013
Measurement of Acute Phase Proteins in Flamingos with Chronic Pododermatitis. Katie Delk DVM, Ray F. Wack, DVM
UC Davis Wildlife Health Center Fellowship [redacted]
Sacramento Zoo Conservation Fund Grant [redacted]
University of Miami Lab Grant $892

Ecology and conservation of the Giant Garter Snake in the Central Valley of California. Ray F. Wack, DVM, Eric Hansen.
USBR Water Conservation Grant [redacted]

2012
Population pharmacokinetics of a single subcutaneous dose of sustained release buprenorphine in northern elephant seals (*Mirounga angustirostris*). Christine Molter DVM, Ray Wack DVM.
Sacramento Zoo Conservation Fund [redacted]
OWCN Research Grant $[redacted]

[redacted] Flamingo (*Phoenicopterus ruber*) as measured by applanation tonometry. Christine Molter DVM, Ray F. Wack, DVM, Sathya Chinnadurai DVM, Steven Hollingsworth DVM.
Sacramento Zoo Conservation Fund Grant [redacted]

Fecundity Study of Giant Garter Snakes in the Central Valley of California. Ray F Wack, DVM, Eric Hansen.
Sacramento Area Flood Control Agency [redacted]

2011
Pharmacokinetics of Tulathromycin in the Desert Tortoise (Gopherus agassizii)
Raymund Wack, MS, DVM, DACZM, Matt Kinney, DVM, Nadine Lamberski, DVM, DACZM, Lisa Tell, DVM, PhD, DABVP (Avian), DACZM

Center for Companion Animal Health Grant [redacted]
Sacramento Zoo Conservation Fund Grant. $[redacted]

2010
Minimum anesthetic concentration of sevoflurane in captive thick-billed parrots (*Rhynchopsitta pachyrhyncha*) Kristen Phair, DVM, (Zoological Medicine Resident) R. Scott Larsen, DVM, MS, DACZM, Raymund Wack, DVM, MS, DACZM, Bruno H. Pypendop, DrMedVet, DrVetSci.
VMTH Resident Research Grant. $1,000
Center for Companion Animal Health Grant [redacted]
Sacramento Zoo Conservation Fund Grant. $[redacted]

2009
[redacted] Investigators Ray F Wack, Eric Hansen Fecundity Study of Giant Garter Snakes in the Central Valley of California. Sacramento Area Flood Control Agency

Validation of Lactate Measurement in American Flamingo (*Phoenicopterus Ruber*) Plasma And Correlation With Duration and Difficulty of Capture. Anne Burgdorf, DVM, Kate Hopper, BVSc, DACVECC , Mike Ziccardi, DVM, Ph.D, R. Scott Larsen, DVM, MS, DACZM, Raymund Wack, DVM, MS, DACZM,
VMTH Resident Research Grant. [redacted].
Sacramento Zoo Conservation Fund Grant. [redacted]

2008
[redacted] Co-Investigator Amanda M. White , E. Scott Weber, Raymund F. Wack, Principle Investigator R. Scott Larsen, Comparison of blood values and physiological parameters of 30 koi (*Cyprinus carpio*) using MS-222 and metomidate anesthesia. Center for Companion Animal Health.

[redacted] Co-Investigator Eric C. Hansen , Ray F. Wack, Robert H. Poppenga, DVM, PhD, DABVT, Christine Kreuder Johnson, VMD, MPVM, PhD. Implementation of Priority 1, Priority 2, and Priority 3 Recovery Tasks for Giant Garter Snake (Thamnophis gigas) – Comparative pathology, health, and contaminant exposure within San Joaquin Valley and Sacramento Valley giant garter snake populations. RFP # 08SF200001. Central Valley Conservation Program and Central Valley Project Improvement Act Habitat Restoration Program

2007
[redacted] Co-Investigator William Love, Raymund Wack. Efficacy of Commercial Rabies Vaccines in Captive Wild Felids. Sacramento Zoo Conservation Fund.

$[redacted] Co-Investigator Jennifer Waldoch, Raymund Wack. Establishment of the Pharmacokinetic Parameters of Long Acting Ceftiofur in Chinese Goral. Sacramento Zoo Conservation Fund.

2006
[redacted] Co-Investigator Deena Brenner, DVM, R. Scott Larsen, DVM, MS, Dipl. ACZM, Raymund Wack, DVM, MS, Dipl. ACZM, Peter J Dickinson, BVSc, PhD, Dipl ACVIM (Neurology), Peter Pascoe, BVSc, DACVA, DVA, DECVA, MRCVS, Development Of A Brachial Plexus Nerve Block Technique For Perioperative Analgesia In Mallard Ducks. Center for Companion Animal Health (CCAH) Research Grant.

2005
[redacted] Co-Investigator – Julio Mercado, Scott Larsen, Bruno Pyendop , Ray Wack. Approximation Of The Minimal Anesthetic Concentration (MAC) Of Isoflurane In Captive Thick-Billed Parrots (*Rhynchopsitta pachyrhyncha*). Center for Companion Animal Health (CCAH) Research Grant, VMTH Resident Research Award.

2004
$[redacted] Co-Investigator – Ray Wack, Cora Singleton, Scott Larsen, Frozen Meat Diet Quality Control and Safety. Sacramento Zoo, Columbus Zoo, 3M Microbiology Division

[redacted] Investigator – Ray Wack, Scott Larsen, Survey of blood lead and mercury levels in Giant Garter Snakes from the Central Valley of California, Conservation Fund of the Sacramento Zoo.

2003

[redacted] Co – Investigator, Evaluation of a Gamma Interferon Enzyme Immunoassay, a Multiple-Antigen ELISA, and an Antigen 85 Immunoassay for Screening for *Mycobacterium tuberculosis* Infection in Orangutans (*Pongo pygmaeus*) N. Boedeker, R. Scott Larsen, R Wack, Nicholas W. Lerche, M.D. Salman, JoAnn Yee, Michael Ziccardi, Funding source MAZURI Research Grant

2002

[redacted] Investigator – Raymund Wack, Scott Larsen, Clinical Evaluation of an Avian Chemistry Rotor. Abaxis Corporation

2000

[redacted] Co-Investigator – Raymund Wack, Grant Frazer, Ultrasonographic Imaging of the reproductive tract of the female Scimitar-Horned Oryx. OSU Columbus Zoo Co-Operative Research Grants.

[redacted] Co-Investigator – Raymund Wack, Brad Coupe, Mate location in Sidewinder Rattlesnakes. OSU Columbus Zoo Co-Operative Research Grants.

1999

[redacted] Co-Investigator – Raymund Wack, Jerry Masty, A novel way to extend the educational missions of the Columbus Zoo and the College of Veterinary Medicine: Plastination. OSU Columbus Zoo Co-Operative Research Grants.

1998

[redacted] Co-Investigator – Raymund Wack, Disease Surveillance of Free-Living Waterfowl and Rodents and Their Potential Health Risks for Zoological Collections. OSU Columbus Zoo Co-Operative Research Grants.

[redacted] Co-Investigator – Raymund Wack, Studies on the Ecology and Epidemiology of Meningeal Worm Infection as a Foundation for the Development of Control Strategies Applicable to Non-Domestic Ungulates. OSU Columbus Zoo Co-Operative Research Grants.

1997

[redacted] Co-Investigator - Raymund Wack, Heart Rate Variability in Great Apes - A Pilot Study. OSU Columbus Zoo Co-Operative Grants.

1996

[redacted] Co-Investigator - Raymund Wack, Feline Immunodeficiency Virus as a Neurotropic Lentivirus in the Lion. OSU Columbus Zoo Co-Operative Grants.

1995

[redacted] IMS Conservation Grant - Principle Investigator - Raymund Wack, Pooling of Medical Records and AAZV BBS

[redacted] Co-Principle Investigator - Raymund Wack, Conservation, Reproductive Behavioral Ecology and Population Genetics of the Timber Rattlesnake (*Crotalus horridus*) OSU / Columbus Zoo Co-operative Grants

[redacted] Co-Principle Investigator - Raymund Wack, Comparison of the Electrocardiogram of Wild and Captive Wolves OSU / Columbus Zoo Co-operative Grants

[redacted] Co-Principle Investigator - Raymund Wack, Plastination: A Unique Method of Preserving Animal Specimens for Education and Demonstration OSU/ Columbus Zoo Co-operative Grants

[redacted] Co-Principle Investigator - Raymund Wack, Adsorption Spectra of Feline Hemoglobin in the Visible and Near Infrared Region OSU/Columbus Zoo Co-operative Grants

1993

[redacted] Co-Principal Investigator - Raymund Wack, Bacterial Gastritis in Cheetahs OSU/Columbus Zoo Co-operative Grants

[redacted] Co-Principal Investigator - Raymund Wack, Further Characterization of a Unique Isolate of Feline Immunodeficiency Virus from Captive Lions OSU/Columbus Zoo Co-operative Grants

1992

[redacted] Principal Investigator - Raymund Wack, Systemized Infant Growth Rate Records - Columbus Zoo Enrichment Grants

1990

[redacted] Principal Investigator - Raymund Wack, Vaccination of Cheetahs OSU/Columbus Zoo Co-operative Grants

[redacted] Principal Investigator - Raymund Wack, Analysis of Zoo Diets OSU/Columbus Zoo Co-operative Grants

J. Publications: Refereed Journals – first author

2017. Wack, Ray F., Eric C. Hansen, Chris K. Johnson, and Robert Poppenga. Bacterial Flora of the Giant Garter Snake (*Thamnophis gigas*) and Valley Garter Snake (*Thamnophis sirtalis fitchi*) in the Central Valley of California. Western Wildlife 4:61-71.

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1997. Wack, Ray F. D.V.M., M.S., A. A. Jones D.V.M. Suspected Neonatal Isoerythrolysis in two Baird's Tapirs (*Tapirus Bairdii*). Journal of Zoo and Wildlife Medicine 28(3): 285-289.

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1986. Wack, Raymund F., Robert L. Hamlin D.V.M. The Use of the Chicken Heart in a Langendorff Preparation. Laboratory Animal Science 36(2): 186-188.

2018. Survey for equine herpesviruses in polar bears (ursus maritimus) and exotic equids housed in US AZA Institutions. John A. Flanders, Raymund F. Wack, Nicola Pusteria, Samantha M. Mapes, Darin Collins and Kathryn C Gamble. Journal of Zoo and Wildlife Medicine 49(3).

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2016. Hematology and Plasma Biochemistry Intervals for Captive-Born California Tiger Salamanders (Ambystoma Californiense). Sean Brady, D.V.M., Anne Burgdorf-Moisuk, D.V.M., Dipl. A.C.Z.M., Philip H. Kass, D.V.M., M.P.V.M., M.S., Ph.D., Dipl. A.C.V.P.M., Jacqueline Brady, D.V.M., and Raymund F. Wack, D.V.M.,M.S., Dipl. A.C.V.M. Journal of Zoo and Wildlife Medicine 47(3): 731–735.

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2016. Successful Treatment of Suspected Pulmonary Arterial Hypertension in a Mealy Amazon Parrot Amazona farinose) Sean M. Brady, DVM, Anne Burgdorf-Moisuk, DVM, Dipl ACZM, Sarah Silverman, DVM, Dipl ACVIM (Cardiology), and Raymund F. Wack, DVM, MS, Dipl ACZM Journal of Avian Medicine and Surgery 30(4):368–373.

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M.P.V.M., Heather K. Knych, D.V.M., Ph.D., Dipl. A.C.V.C.P., Sathya K. Chinnadurai,

D.V.M., M.S., Dipl. A.C.Z.M., Dipl. A.C.V.A.A., and Raymund F. Wack, D.V.M., M.S., Dipl. A.C.Z.M. Journal of Zoo and Wildlife Medicine 46(1): 52–6.

2015. Acute Phase Protein and Electrophoresis Protein Fraction Values for Captive American Flamingos (*Phoenicopterus Ruber*). Katie W. Delk, D.V.M., Raymund F. Wack, D.V.M., M.S., Dipl. A.C.Z.M., Anne Burgdorf-Moisuk, D.V.M., Dipl. A.C.Z.M., Philip H. Kass, D.V.M., Ph.D., Dipl. A.C.V.P.M. (Epidemiology), and Carolyn Cray, Ph.D. Journal of Zoo and Wildlife Medicine 46(4): 929–933.

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2000. Anderson, N.L., D.V.M.and Raymund F. Wack, D.V.M., M.S. Anesthetic Procedures in Exotic Pets *in Handbook of Veterinary Anesthesia* by W. Muir and J. Hubbell. Third Edition. Mosby -Year Book, Inc.

1999. Podell, M., R.F. Wack, S. VandeWoude. Neurological Complications of Feline Immunodeficiency Virus (FIV) in Lions. Proceedings American Association of Zoo Veterinarians Annual conference. Columbus OH. Pp. 256- 258.

1998. Raymund F. Wack, Gastritis in Cheetahs. In Zoo and Wild Animal Medicine Current Therapy 4 by M. Fowler and R Miller.

1997. Grossenbaugh, D.A., Raymund F. Wack, D. James, O. Allen, W. Muir Absorbance Spectra of Feline Hemoglobins in the Visiable and Near Infrared Regions. Annual Proceedings of American Association of Zoo Veterinarians.

1995. Anderson, N.L., D.V.M.and Raymund F. Wack, D.V.M., M.S. Anesthetic Procedures in Exotic Pets *in Handbook of Veterinary Anesthesia* by W. Muir and J. Hubbell. Mosby -Year Book, Inc.

1995. Wack, Raymund F. Water Quality Testing for Practitioners. Annual Proceedings of WEZAM Exotics Conference, Madison WI

1995. Wack, Raymund F. Gill Function and Parasites. Annual Proceedings of WEZAM Exotics Conference, Madison WI

1994. Wack, Raymund F., D.V.M., M.S. and Douglass Warmolts. Book Review of Fish Medicine by M. Stoskopf published in Copeia 1994 (2) 548-549.

1994. Wack, Ray F., D.V.M., MS, L. W. Kramer. An Unusual Presentation of Osteomyelitis in a Snow Leopard (*Panthera uncia*) Cub. 1994 Proceedings American Association of Zoo Veterinarians 1147-148.

1992. Wack, Ray F., D.V.M., L. Kramer D.V.M., M.J. King BS, M. Marr B.S., M. Lyons B.S., L. Lafrado Ph.D. Isolation and Preliminary Characterization of a Unique Feline Immunodeficiency Virus from a Captive Lion (*Panthera leo*). Proceedings of Joint Meeting of AAZV / AAWA p355-359 and poster presentation.

1992. Wack, Ray F., D.V.M., MS and D.I. Warmolts. Suspected Gas Bubble Disease in Captive Loggerhead Sea Turtles. Poster Presentation AAZPA National Conference.

1991. Wack, Ray F., D.V.M. The Vaccinations of Cheetahs. 1991 Proceedings American Association of Zoo Veterinarians p. 294-297.

1991. Wack, Ray F., D.V.M. Control of Avian Parasites. Midwest Avian Research Expo p61-64.

1990. Wack, Ray F., D.V.M., Lynn W Kramer D.V.M., William Cupps and Stacy Katz, B.S. Antibody Titer Response of Cheetah (*Acinonyx jubatus*) Cubs to Vaccination. 1990 Proceedings of American Association of Zoo Veterinarians. p . 147-149.

1990. Wack, Ray F., D.V.M., Lynn W Kramer D.V.M., William Cupps, Stacy Katz B.S.. Growth Rate of 21 Captive Mother-raised Cheetah Cubs (*Acinonyx jubatus*). Poster Presentation. Proceedings of the American Association of Zoo Veterinarians p. 308.

L. Faculty and Departmental Responsibilities

Jan 2014 – Present	UCDavis Clinical Education Committee	Zoological Medicine advisor
May 2001 – present	UC Davis Zoological Medicine Residency	Program Coordinator

January 2000 – present	UCDavis Zoological Medicine Service	Service Chief
August 2002 – present	UCDavis WAAM student club	Faculty Advisor
Oct 2001 – present	UCDavis SVM Zoo Med Track	Track Coordinator
March 2012 – 2016	UC Davis Zoological Medicine faculty search committee	
August 2002 – 2014	UCDavis SVM Track Coordination Committee Committee Member	
March 2005 – Nov 2005	UCDavis SVM wildlife clinician faculty search committee	
June 1995 – Aug 2000	Columbus Zoo Veterinary Preceptorship	Program Administrator
Jan 1993 – Aug 2000	VME 608 Course Planning Committee	Committee Member
July 1991 – Aug 2000	General Advising	Avg. 4 students per qtr.
July 1991 – Aug 2000	Student Chapter AAZV	Faculty Advisor

M. Other Service and Professional Assignments

Dates	Institution	Position/Title
October 2009 – present	ACZM	Chairperson Credentials Committee
May 2009 – present	AZA	Grevy Zebra SSP Veterinary Advisor
April 2003 – present	Sacramento Zoo	Conservation Committee Chairman
Jan 2000 – present	AZA	Accreditation Inspector
Jan. 2000 - present	ACZM	Credentials Committee
Dec 1994 - present	Zoo Biology	Review manuscripts for publication
Feb 1993 - present	Journal of AAZV	Review manuscripts for publication
Oct 1991 - present	AAZV	Information Resources Committee Member
May 2017	AZA	Miller Park Zoo Accreditation Inspection
May 2016	AZA	Jackson Zoo Accreditation Inspection
June 2015	ACZM	Hosted Strategic Plan retreat
Oct 2012	Ca DFW	Sea Otter capture and telemetry surgeries
June 2012	AZA	Zoo Boise Accreditation Inspection
Feb 2011	AZA	Alameda Zoo Accreditation Inspection
Oct 2011	AAZV	Carnivore Session Chair
Jul 2011	ACZM	Job analysis Strategic Retreat
Nov 2009	AZA	Santa Barbara Zoo Accreditation Inspection
Oct 2007	AAZV	Primate Session Chair
July 2007	AZA	Zoo Boise Accreditation Inspection
Feb 2006	AZA	Micke Grove Zoo Accreditation Inspection
Jan 2005	AZA	Micke Grove Zoo Accreditation Inspection
Jan. 2000 – 2008	AZA	Animal Health Committee
Oct 2002 – Sep 2003	AAZV	Nominations Committee Chairman
Oct 2002 – Sep 2003	AAZV	Ethics Committee Chair, Executive Board
Sep 2001 – Oct 2002	AAZV	President, Member of Executive Board
Sep 2000 – Sep 2001	AAZV	President-elect, Program Chair,
Oct. 1999 – Sep 2000	AAZV	Vice-President, Member of Executive Board
Oct. 1999	ARAV	Local Host for Annual Conference
Oct. 1999	AAZV	Local Host for Annual Conference
Oct. 1998 – Sep 1999	AAZV	Secretary, Member of Executive Board
Oct. 1997 - Sep 1998	AAZV	Treasurer, Member of Executive Board
Oct. 1997	AAZV	Anesthesia Section Chairman for Conference
Jan 1996 – Dec 1999	AAZV	World Wide Web Page Manager
July 1991 – Aug 2000	Columbus Zoo Committee Member	Conservation and Collection Management
Oct 1996 - Oct 1997	AAZV	Anesthesia Section Chair for 97 Conference
Aug 1995 - Mar 96	AVMA	Section Sysop NOAH/AAZV
Jan 1995 - Mar 96	ISIS	Zoo Vet BBS Sysop
Mar 1995 - Jan 96	Journal of AAZV	Special Issue Editor
Oct 1994 - Sep 96	AAZV	Executive Committee Member
Nov 1992 - Sep 96	AAZV	ISIS/Computer Data Committee Chairman
Feb 1991 - Jun 95	ARCAS	Veterinary Advisor for Rehab Center

N. Professional/Academic Association Memberships

Association of Avian Veterinarians (AAV)
American Association of Zoo Veterinarians (AAZV)
American College of Zoological Medicine (ACZM)
Association of Zoos and Aquariums (AZA)
Association of Reptile and Amphibian Veterinarians (ARAV)
American Veterinary Medical Association (AVMA)
Wildlife Disease Association (WDA)
The Wildlife Society (TWS)

O. Awards and Honors

2018 UCDavis SVM Faculty Clinical Excellence Award
2011 ACZM Presidential Service Award
2010 Sacramento Zoo Summer Camp Teacher of the Week
1999 AAZV Presidential Service Award
1997 AAZV Presidential Service Award
1996 AAZV Presidential Service Award
1995 AAZV Presidential Service Award
1994 AAZV Presidential Service Award
1987 SCAVMA Service Award
1985 SCAVMA Service Award
1976 Eagle Scout

P. International Experiences

Position/Title	Country	Dates
Mountain Gorilla Scientific Advisory Committee	Rwanda	2008 - Present
Ross Veterinary School	St. Kitts	May 2006
CBSG Veterinary Training Workshop	Chengdu China	December 1999
CBSG Captive Panda Health Assessment	Beijing China	March 1998
ARCAS Site Visit / Veterinary Advisor	Guatemala, CA	June 1995
Veterinary Advisor for ARCAS	Guatemala, CA	February 1993

Q. Selected Invited Presentations

Organization	Title of Presentation	Location and Date
AAZV/EAZV Conference	Amdoparvovirus discovery in red pandas	Prague, Czech Republic 2018
USGS/USFWS GGS Recovery	Healthy survey results for giant garter snakes	Elk Grove, CA Oct 2016
Tuleyome Wildlife Conservation	The role of Zoos in Wildlife Conservation	Davis, CA Nov 2016
Grevy Zebra SSP	Update on EHV-1 in zebra and bears	Memphis, TN 2014
Grevy Zebra SSP	Morbidity and Mortality Survey results	Chattanooga, TN 2012
Sacramento Dental Society	Dentistry in a Zoo Setting	Sacramento CA May 2010
C.L. Davis Comparative Pathology	Canine Distemper in Red Pandas (D. Montali presenter)	New Orleans LA Sep00
Association of OR Nurses	Diversity of Practice – Surgery Skills at the Zoo	Columbus OH Apr00
North Am. Vet. Conf.	Pemphigus in hedgehogs, FIV in Lions Management and Diseases of Cheetahs	Orlando FL Jan 00
Columbus Academy of Vet Med.	Zoo Medicine and Conservation	Columbus Zoo Nov 98

Cleveland Academy of Vet Med	Reptile Medicine (4 hrs)	Cleveland Zoo Oct 97
AAZV	Information Resources for Wildlife Vets	East Lansing MI Aug 95
Ohio State University	Reptile Medicine for Practicing Vets 12 hours of lectures	Columbus OH May 95
WEZAM	Water Quality Testing for Practitioners	Madison, WI Apr 95
WEZAM	Gill Function and Parasites	Madison, WI Apr 95
AAZV	Unusual Presentation of Osteomyelitis	Pittsburgh, PA Oct 94
AAZV	MedARKS Training Wetlab	Pittsburgh, PA Oct 94
Mid-Ohio Herpetologists	Wildlife Conservation in Guatemala	Columbus Zoo Jun 93
AAZV	FIV in Lions Poster	Oakland CA Nov 93
Mid Ohio Exotic Bird Club	Wildlife Conservation in Guatemala	Columbus OH Aug 93
Golden Crescent Cage Bird Club	Wildlife Conservation in Guatemal	Cleveland OH Jul 93
Mid Ohio Herpetologists	Sea Turtles - Scientific Presentation	Columbus Zoo Feb 93
AAZV/MedARKS	Mid-year meeting - organized mtg	Columbus Zoo Mar 93

R. Continuing Education Attended

2018 American Association of Zoo Veterinarians Annual Conference, Prague Czech Republic
2017 American Association of Zoo Veterinarians Annual Conference, Dallas, TX
2017 AZA mid-year meeting, Albuquerque, NM
2016 Atlantic Coast Veterinary Conference, Atlantic City NJ
2015 American Association of Zoo Veterinarians Annual Conference, Portland OR
2014 American Association of Zoo Veterinarians Annual Conference, Orlando, FL
2014 AZA mid-year meeting, Memphis TN
2013 American Association of Zoo Veterinarians Annual Conference, Salt Lake City, UT
2012 American Association of Zoo Veterinarians Annual Conference, Oakland CA
2011 AZA mid-year meeting, Chattanooga, TN
2011 Biosound Esoate Small Animal Ultrasound 16 hr course, San Luis Obispo CA
2011 American Association of Zoo Veterinarians Annual Conference, Kansas City MO
2010 American Association of Zoo Veterinarians Annual Conference, South Padre Island TX
2010 Zoos and Aquariums Committing to Conservation, Seattle WA
2009 American Association of Zoo Veterinarians Annual Conference, Tulsa OK
2008 Amphibian Biology and Management Profesional Training Program, Toledo OH
2008 American Association of Zoo Veterinarians Annual Conference, Knoxville TN
2007 Canine Medicine Symposium, UC Davis CA
2006 American Association of Zoo Veterinarians Annual Conference, Tampa FL
2006 California Veterinary Medical Association Annual Conference, San Francisco CA
2005 American Association of Zoo Veterinarians Annual Conference, Omaha NE
2005 UC Davis University Communications Media Training, Davis CA
2004 American Association of Zoo Veterinarians Annual Conference, San Diego CA
2004 Spring CE California Veterinary Medical Association, Yosemite CA
2003 Access 2000 level 1 software training, Sacramento CA
2003 American Association of Zoo Veterinarians Annual Conference, Minneapolis MN
2002 Excel 2000 level 2 software training, Sacramento CA
2002 American Association of Zoo Veterinarians Annual Conference, Milwaukee WI
2002 Association of Avian Veterinarians Annual Conference, Monterey CA
2001 American Association of Zoo Veterinarians Annual Conference, Orlando FL
2001 Association of Reptilian and Amphibian Veterinarians Annual Conference, Orlando FL
2000 American Association of Zoo Veterinarians Annual Conference, New Orleans LA
2000 North American Veterinary Conference, Orlando FL
1999 American Association of Zoo Veterinarians Annual Conference, Columbus OH
1998 American Association of Zoo Veterinarians Annual Conference, Omaha NE
1998 Association of Avian Veterinarians Annual Conference, Minneapolis MN
1997 Association of Reptilian and Amphibian Veterinarians Annual Conference Houston TX
1997 American Association of Zoo Veterinarians Annual Conference Houston TX
1997 ACZM Training Course, Raleigh NC
1996 American Association of Zoo Veterinarians Annual Conference, Puerto Vallarto MX

1995 American Association of Zoo Veterinarians Annual Conference, East Lansing MI
1995 ACZM Training Course, Raleigh NC
1995 WEZAM Exotics Conference, Madison WI
1995 Feline Respiratory Disease Seminar, Columbus OH
1995 OVMA Annual Conference, Columbus OH
1994 American Association of Zoo Veterinarians Annual Conference, Pittsburgh PA
1994 Food Animal Medicine Short Course, Columbus OH
1994 North American Veterinary Conference, Orlando FL
1993 Fish Health Management University of Georgia, Athens GA
1993 American Association of Zoo Veterinarians Annual Conference, St. Louis MO.
1992 Association of Avian Veterinarians Annual Conference, New Orleans LA
1992 American Association of Zoo Veterinarians Annual Conference, Oakland CA
1992 CBSG International Conference on Implications of Infectious Diseases for Captive Propagation and Reintroduction Programs of Threatened Species, Oakland CA

Benjamin P. Weitzman
Wildlife Biologist
U.S. Geological Survey

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Objective

###
Full Curriculum–Vitae 2019

Education

University of Alaska Fairbanks
September 2015 - Present
Ph.D. Candidate, Marine Biology
Advisors: Dr. Brenda Konar & Dr. Daniel Esler

University of California, Santa Cruz
September 2010 - March 2013
M.A. Ecology & Evolutionary Biology
Advisors: Dr. M. Tim Tinker & Dr. James A. Estes

University of California, Santa Cruz
September 2004 - June 2008
B.S. Marine Biology
Advisor: Dr. Terrie M. Williams

Employment

Wildlife Biologist – Pathways Student Trainee (GS-09/11)
US Geological Survey (Alaska Science Center), February 2013 - Present

- Manage and conduct scientific investigations of nearshore ecosystems as part of the Gulf Watch Alaska (co-PI) monitoring program and on-going collaborations with other federal and academic institutions.
- Liaison between USGS Alaska Science, USGS Western Ecological Research Center, University Alaska Fairbanks, and other institutions for coordination of collaborative intra- and inter-agency projects.
- Responsible for leading dynamic projects in the field, coordinating field logistics, and managing multiple concurrent projects.
- Contributions to reports and publications: writing, data analysis, and synthesis across inter-disciplinary projects.
- Participation in public speaking and outreach about natural history and nearshore ecology (see presentations).
- Development of proposals to other funding agencies.
- Specific skills include conducting sea otter captures using highly specialized CCR (Closed Circuit Rebreather) and SCUBA diving techniques, tracking of tagged sea otters using telemetry, maintenance of watercraft and sensitive dive equipment, surveys of benthic communities, marine bird and mammal surveys, sea otter aerial surveys using ISU methodology, sea otter feeding observations, habitat and invertebrate resource sampling using SCUBA, field logistics management, data

management, data analysis in contribution to summaries, reports, and publications.
- Supervisors: Dr. Daniel Esler (ASC).

Graduate Student Researcher/Biologist (GS-07, GS-09)

US Geological Survey (Western Ecological Resource Center & Alaska Science Center), April 2010- February 2013

- Duties included conducting sea otter captures using highly specialized CCR (Closed Circuit Rebreather) and SCUBA diving techniques, tracking of tagged sea otters using telemetry, census of the CA sea otter population, maintenance of watercraft and sensitive dive equipment, surveys of intertidal monitoring sites, marine bird and mammal surveys, sea otter aerial surveys using ISU methodology, sea otter observations using established techniques, habitat and invertebrate resource sampling using SCUBA, data management and analysis.
- Time was split between the Western Ecological Resource Center – Santa Cruz Field Station from September-April and the Alaska Science Center, Anchorage, from April-August each year.
- Gained experience in coordinating field logistics, leading dynamic projects in the field, synthesis of large data sets, Public speaking on natural history and nearshore ecology (see presentations), and coordination of collaborative intra- and inter-agency projects.
- Supervisors: Dr. Tim Tinker (WERC, retired), Jim Bodkin (ASC, retired), & George Esslinger (ASC).

Scientific Aide

California Dept. Fish & Wildlife, March 2008 – April 2010

- Primary duties as a field biologist conducting sea otter captures using highly specialized rebreather diving techniques, tracking of tagged sea otters using telemetry, census of the southern sea otter population, and recovery of dead sea otter carcasses. Fulfilled duties as a necropsy technician to assess pathology of wildlife, focused on sea otters, but also including marine birds, sea turtles, and terrestrial mammals. Trained in sterile technique and processing of water samples as part of a pollutant and pathogen transmission project.
- Supervisor: Jack Ames (retired) & Dr. Dave Jessup (retired)

Boat Yard/Facilities Assistant

UCSC, January 2007 - July 2008

- Providing support to UCSC's scientific diving program boat yard and facilities.
- Experience in construction, welding, fiberglass, boating and diving equipment maintenance, innovating techniques to achieve scientific goals, and heavy machinery operation.
- Supervisor: Pete dal Ferro (UCSC/USGS) & Nate Moore (UCSC)

Volunteer Experience

Marine Mammal Physiology Project, Animal Trainer

UCSC, October 2005 – May 2008

- Required to perform 20 hours of service per week in the husbandry and training of bottlenose dolphins, sea lions, seals, and sea otters for physiological studies to answer questions on metabolics and energetics.
- Experience in leadership, team building, animal handling, animal training, husbandry,

and data collection and management.
- Supervisor: Traci Kendall, Principal Investigator: Dr. Terrie Williams

PISCO Subtidal Technician
UCSC, Summer 2007: Partnership for the Interdisciplinary Studies of Coastal Oceans (PISCO)
- Conducted subtidal biodiversity surveys on temperate reef ecosystems across the central coast of California. Surveys included reef structure and biotic cover, macro-algae, and invertebrates. Long term ecological monitoring, recruitment and baseline monitoring for newly input Marine Protected Areas. Conducted fieldwork in all oceanic conditions, and from many types of watercraft. All surveys were conducted on SCUBA.
- Supervisor: Randolf Skrovan, Principal Investigator: Dr. Mark Carr

Teaching Experience
- UC Santa Cruz TA-ship: *Ecology*, led by Prof. James Estes

Mentoring Experience
- Undergraduate through the Alaska Native Science and Engineering Program (ANSEP) partnership with USGS: Yosty Storms
- Undergraduate Mentorship: Alaska Pacific University student thesis project, Kaitlyn Lawton, on sea urchin energetics.
- Guided and worked with multiple volunteers from USGS

Relevant Experience & Training

- **GIS:** Spatial data analysis, visualization, and collection in ESRI ArcDesktop10
- **R:** Data analysis, modeling, and visualization.
- **PRIMER-e + PERMANOVA:** Multivariate data analysis and visualization for biophysical synthesis.
- **Motorboat Operator Certification Course (MOCC)**: Dept. of Interior for small boat operations.
- **USGS Certified Deckhand:** Cook, crew, and science on a 50’ research vessel. Safety management, maintenance, routine operation, and overseeing science crews.
- **American Academy of Underwater Sciences (AAUS)** Current to 100’ depth
  - **UCSC Dive Safety Board Member**: 2007-2008
  - **Open Water Scuba Instruction:** PADI #191966, Over 100 students certified across basic, advanced, rescue, and divemaster ratings.
  - Drysuit, Nitrox, and Closed-circuit Rebreather certified.
- **CPR, First Aid, Oxygen administration:** Wilderness first aid for remote work in AK
- **Firearms and Defense Against Wildlife:** USGS
- **Software:**
  - Microsoft Office: Access, Excel, Powerpoint, and Word
  - Adobe: Dreamweaver, Illustrator, Photoshop
  - Data Acquisition: HOBOware, Castaway, DNRGPS, Image-J
  - Other Statistics: SYSTAT, SAS, JMP

Contributions to the Field

Benjamin Phillip Weitzman

Peer-Reviewed Publications & Reports

- Rasher, D., Steneck, R., Estes, J., Halfar, J., Kroeker, K., Ries, J., Chan, P., Fietzke, J., Konar, B., Norley, C., **Weitzman, B.,** and Westfield, I. (in review) Climate Change Amplifies Trophic Cascades in a Kelp Forest Ecosystem. *Science.*
- Tinker, M.T., Tomoleoni, J., **Weitzman, B.,** 12 others… (2019) Comparing a clean and dirty ocean: Sea otter health, ecology, and behaviour in Big Sur VS Monterey, CA. *USGS Open File Report.* Western Ecological Research Center, U.S. Geological Survey, Sacramento, CA.
- Garlich-Miller, J., Esslinger, G., and **Weitzman, B**. (2018) Aerial surveys of sea otters (*Enhydra lutris)* in lower cook inlet, Alaska, May, 2017. *USFWS Technical Report MMM 2018-01*. U.S. Fish & Wildlife Service, Marine Mammals Management. Anchorage, AK.
- Ebert, T., Barr, L., …, **Weitzman, B.,** 30 others… (2018) Size, growth, and density data for shallow-water sea urchins from Mexico to the Aleutian Islands, Alaska, 1956–2016. *Ecology*, *99*(3), 761-761.
- Coletti, H., Esler, D., Ballachey, B., Bodkin, J., Esslinger, G., Kloecker, K., Monson, D., Robinson, B., **Weitzman, B.**, Dean, T., and Lindeberg. M. (2018) Gulf Watch Alaska: Nearshore benthic systems in the Gulf of Alaska. Long-Term Monitoring Program (Gulf Watch Alaska) Final Report (*Exxon Valdez* Oil Spill Trustee Council Project 16120114-R), *Exxon Valdez* Oil Spill Trustee Council, Anchorage, Alaska.
- **Weitzman, B**., Bodkin, J., Kloecker, K., and Coletti, H. (2017) SOP for monitoring intertidal bivalves on mixed-sediment beaches — version 2.0: Southwest Alaska Inventory and Monitoring Network. Natural Resource Report NPS/SWAN/NRR—2017/1443. National Park Service, Fort Collins, Colorado.
- Konar, B., Edwards, M. S., Bland, A., Metzger, J., Ravelo, A., Traiger, S., & **Weitzman, B.** (2017). A swath across the great divide: kelp forests across the Samalga Pass biogeographic break. *Continental Shelf Research*.
- Konar, B., Iken, K., Coletti, H., Monson, D., & **Weitzman, B.** (2016). Influence of Static Habitat Attributes on Local and Regional Rocky Intertidal Community Structure. *Estuaries and Coasts*, pp 1-11.
- Ballachey, B., Bodkin, J., Coletti, H., Dean, T., Esler, D., Esslinger, G., Iken, K., Konar, B., Lindeberg, M., Monson, D., Shephard, M., and **Weitzman, B**. (2015) Variability within Nearshore Ecosystems of the Gulf of Alaska. Synthesis Report for Gulf Watch Alaska Long Term Monitoring Program, pp 1-7.
- Esslinger, G., Bodkin, J., & **Weitzman, B.,** (2015) Aerial Sea Otter Abundance Surveys – Prince William Sound, Alaska, Summer 2014. Administrative report for USFWS Region 7, pp 1-9.
- **Weitzman, B.,** Esslinger, G., Bodkin, J., (2013) Using a Diver-operated Suction Dredge to Evaluate the Effects of a Top-predator on Subtidal Soft-sediment Infaunal Bivalve Communities, in Stellar, D., Lobel, L., eds., Proceedings of the American Academy of Underwater Sciences 31st Symposium, September 24-29, 2012. Monterey, CA: Diving for Science 2012. pp 103-109
- Esslinger, G., Bodkin, J., **Weitzman, B.** (2013) Sea otter Population Abundance and Distribution in Glacier Bay, Alaska. Administrative Report for USFWS Region 7, pp 1-11.
- Coletti, H., Esslinger G., and **Weitzman, B.** (2013) Sea Otter Abundance in Katmai National Park and Preserve: Results from the 2012 Aerial Survey, Southwest Alaska Network Inventory and Monitoring Program. Natural Resource Technical Report. National Park Service, Fort Collins, Colorado.

Peer-reviewed Published Datasets

- Kloecker, K. A. and **Weitzman, B.P.** (2018) Gulf Watch Alaska Nearshore Component:

Intertidal Soft-Sediment Invertebrates from Prince William Sound, Katmai National Park and Preserve, and Kenai Fjords National Park, 2007-2015: U.S. Geological Survey data release

- Monson, D. H., Kloecker, K. A., Ballachey, B. E., Bodkin, J. L., Coletti, H. A., Dean, T. A., Esler, D., Esslinger, G. G., Paszalek, J. and **Weitzman, B.P.** (2016) Gulf Watch Alaska Benthic Component: Marine Water Quality, Water Temperature from Prince William Sound, Katmai National Park and Preserve, and Kenai Fjords National Park, 2006-2014: U.S. Geological Survey data release
- Kloecker, K. A., Ballachey, B. E., Bodkin, J. L., Coletti, H. A., Dean, T. A., Esler, D., Esslinger, G. G., Lindeberg, M. R., Monson, D. H., Paszalek, J. and **Weitzman, B.P.** (2016) Gulf Watch Alaska Nearshore Component: Intertidal Mussel Site Data from Prince William Sound, Katmai National Park and Preserve, and Kenai Fjords National Park, 2008-2015: U.S. Geological Survey data release

<u>Service</u>

Professional Meetings:

- Western Society of Naturalists Meeting, November 12th, 2010: Talk, "The Effects of Sea Otter Recolonization on Benthic Intertidal Invertebrate Communities in Glacier Bay National Park & Preserve, Alaska"
- Sea Otter Conservation Workshop, Seattle, March 26th, 2011: Talk, "Sea Otter Impacts on Soft-Sediment Intertidal Communities in Glacier Bay National Park & Preserve, Alaska"
- Southern Sea Otter Research Update Meetings, Santa Cruz, February 9th, 2012: Talk, "The effects of sea otters on soft-sediment communities in Glacier Bay, Alaska"
- Southern Sea Otter Research Update Meetings, Santa Cruz, February 9th, 2012: Talk, "Exxon Valdez Oil Spill Long Term Monitoring of the Nearshore Environment"
- American Academy of Underwater Sciences, September 29th, 2012: *Talk*, "Using a diver-operated suction dredge to evaluate the effects of a top-predator on subtidal soft-sediment infaunal bivalve communities"
- American Academy of Underwater Sciences, September 29th, 2012: *Talk Co-Author*, "Closed-Circuit Diving Techniques for Wild Sea Otter Capture"
- Alaska Marine Science Symposium, January 24th, 2013: *Talk*, "Colonization in Action: Understanding the impacts of sea otters on soft-sediment invertebrate communities"
- Sea Otter Conservation Workshop. Seattle, WA, February, 2013: *Remote Talk*, "Colonization in Action: Understanding the impacts of sea otters on soft-sediment invertebrate communities"
- Southern Sea Otter Research Update Meetings, February 25th, 2014: *Talk*, "Variation in Body Condition in Sea Otter Populations"
- Alaska Marine Science Symposium, January 20th, 2015: *Poster Co-Author*, "Communities associated with crustose coralline algae reef habitat in the western Aleutian Islands"
- Alaska Marine Science Symposium, January 20th, 2015: *Poster Co-Author*, "Inter-annual and spatial variation in Pacific blue mussels (*Mytilus trossulus*) in the Gulf of Alaska, 2006-2013"
- Alaska Marine Science Symposium, January 20th, 2015: *Poster*, "Implications of recolonization and food limitation for sea otters in soft-bottom habitats of Glacier Bay, AK"

- Sea Otter Conservation Workshop. Seattle, WA, March, 27th 2015: *Talk*, “After two decades in Glacier Bay: Implications of Recolonization and Resource Dynamics for Sea Otters in Soft-Bottom Habitats of the North Pacific”
- Alaska Marine Science Symposium, January 21st, 2016: *Poster*, “Variability in sea urchin population size structure at multiple spatial scales across the Aleutian Islands: implications for sea otters”
- Alaska Marine Science Symposium, January 21st, 2016: *Poster Co-Author*, “Updates of key metrics from long-term monitoring of nearshore marine ecosystems in the Gulf of Alaska: Detecting change and understanding cause”
- Alaska Marine Science Symposium, January 21st, 2016: *Poster Co-Author*, “Multi-agency Efforts to monitor Sea Star Wasting Disease in Alaska: Results and Recommendations for Future Efforts”
- NPS Centennial Science Symposium, Fairbanks, October 2016, *Poster Co-Author “*Updates of key metrics from long-term monitoring of nearshore marine ecosystems in the Gulf of Alaska: Detecting change and understanding cause.”
- NPS Centennial Science Symposium, Fairbanks, October 2016, *Talk*, “Happy as a clam? Variation in bivalve abundance throughout the northeastern Pacific.”
- Western Society of Naturalists Meeting, November 10-13th, 2016: *Talk,* “Variability in green sea urchin demography at multiple spatial scales across the Aleutian Archipelago”
- Western Society of Naturalists Meeting, November 10-13th, 2016: *Poster Co-Author,* “Communities associated with a massive crustose coralline algae reef habitat in the western Aleutian Islands”
- Alaska Bird Conference, Cordova, December 2016. *Talk Co-Author*, “Barrow’s Goldeneye Demographic Responses to Changing Mussel Conditions on Wintering Areas: A Conceptual Model Exercise.”
- Alaska Marine Science Symposium, January 24th, 2017: *Poster Co-Author*, “Spatial variability in mussel size frequency distribution in the Gulf of Alaska.”
- Alaska Marine Science Symposium, January 24th, 2017: *Poster Co-Author*, “Trends in intertidal seastar abundance and diversity across the Gulf of Alaska: looking for effects of seastar wasting.”
- Alaska Marine Science Symposium, January 24th, 2017: *Poster Co-Author*, “Nearshore Marine Consumer Responses to Changing Prey Conditions: Combining Quantitative and Qualitative Model Input into a Conceptual Framework.”
- Alaska Marine Science Symposium, January 24th, 2017: *Talk,* “Can you dig it? Patterns of variability in clam assemblages within mixed-sediment habitats across the Gulf of Alaska”
- Sea Otter Conservation Workshop Seattle, WA, March 17-19 2017: *Talk Co-Author,* “Understanding Trophic Relationships of Sea Otters and Their Effects on Demographic Attributes.”
- Sea Otter Conservation Workshop Seattle, WA, March 17-19 2017: *Talk Co-Author*, “A century of sea otter science and conservation in National Parks”

- Western Society of Naturalists Meeting, November 16-19th, 2017: *Talk Co-Author,* "Mechanisms Leading To The Increase Of The Coarse Spongy Cushion Codium ritteri Within Urchin Barrens"
- Alaska Marine Science Symposium, January 21-25, 2018: *Poster Co-Author*, "Congruence of intertidal and pelagic water and air temperatures during an anomalously warm period in the northern Gulf of Alaska; the "Blob" washes ashore."
- Alaska Marine Science Symposium, January 21-25, 2018: *Poster Co-Author*, "Trends in intertidal sea star abundance and diversity across the Gulf of Alaska: effects of sea star wasting."
- Alaska Marine Science Symposium, January 21-25, 2018: *Poster Co-Author*, "A decade's worth of data: Key metrics from a large-scale, trophic web based long term monitoring program in the northern Gulf of Alaska."
- Alaska Marine Science Symposium, January 21-25, 2018: *Poster Co-Author*, "Mechanisms Leading To The Increase Of The Coarse Spongy Cushion Codium ritteri Within Urchin Barrens"
- Alaska Marine Science Symposium, January 21-25, 2018: *Talk Co-Author,* "Detecting and inferring cause of change in Alaska nearshore marine ecosystem: An approach using sea otters as a component of the nearshore benthic food web"
- Alaska Marine Science Symposium, January, 2018: *Talk*, "Sea urchin demography and ecosystem consequences across the Aleutian Archipelago: A story from the top-down, bottom-up, and side-to-side."

Professional Reviews

- Marine Environmental Research: 2016 (1)
- Journal of Experimental Marine Biology and Ecology: 2017 (2), 2018 (1), 2019 (1)
- Marine Ecological Progress Series: 2018 (1)

Institutional Speaking:

- UCSC/Stanford Species Interactions Workshop, December 3rd, 2011: Talk, "Mucking it Up: The effects of sea otters on soft-sediment intertidal clam communities"
- UCSC Graduate Research Science Symposium, March 3rd, 2012: Talk, "The effects of sea otters on soft-sediment invertebrate communities in Glacier Bay, Alaska"
- USGS Alaska Science Center Seminar Speaker, August, 21, 2012: *Seminar*, "The Effects Of Sea Otters On Soft-Sediment Invertebrate Communities In Glacier Bay Nat'l Park"
- UC Santa Cruz Thesis Defense Seminar, January 18th, 2013: *Seminar*, "The Effects of Sea Otter Colonization on Soft-Sediment Intertidal Prey Assemblages in Glacier Bay, Alaska"
- UAF College of Fisheries & Ocean Sciences Spring Seminar Series, April 5th, 2017: *Talk*, "Biodiversity in the Aleutian Archipelago: trends and causes"
- UAF College of Fisheries & Ocean Sciences Special Seminar, April 19th, 2018. *Talk,* "Assessing drivers of variability in macroinvertebrate abundance and productivity across the northeast Pacific"
- Glacier Bay National Park Service, Ranger Training Series, April 26th, 2018: *Talk*, "Sea otter biology and ecology across the north Pacific"

- UAF College of Fisheries & Ocean Sciences Special Seminar, February 27th, 2019. *Talk*, "Can you dig it? Patterns of variability in clam assemblages across the Gulf of Alaska"

Institutional Reviews:

- USGS Internal reviewer: 2017 (2), 2018 (1)

Public Speaking & Outreach Events:

- Seymour Marine Discovery Center's Science Sunday Series, February 20th, 2011: Public Seminar, "More Than Just a Furry Face: The natural history of sea otters along the Pacific Coast". Santa Cruz, CA
- Sea Otter Awareness Week Lecture Series, September 29th, 2011: Seminar, "The Effects of Sea Otters on Soft-Bottomed Ecosystems". Santa Cruz, CA
- ANSEP School visit, Fall 2015. Alaska Native Science and Engineering program event. Anchorage, AK
- National Park Service video series, Summer 2016. Gulf Watch Alaska nearshore program video. Seward, AK
- Frontiers in Science, Spring 2016. Documentary interview on sea otter research using UAS. Fairbanks, AK
- Gulfwatch PI meeting outreach event, November 2016: Public display on nearshore ecology. Cordova, AK
- Delta Sound Connections article: Unhappy as a clam? 2017-2018. Prince William Sound Science Center.
- Radio interview: Can sea stars make a comeback in Kachemak Bay? August 14. 2017. KBBI Radio, Homer, AK
- UAF Science Potpourri, April 2017: Public outreach event. Fairbanks, AK
- Port Graham Native Corporation listening session, May 18th, 2018: Public discussion with elders. Port Graham, AK

[redacted]

References

[redacted]

Benjamin Phillip Weitzman

[redacted]

Julie L. Yee

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Santa Cruz Field Station, 2885 Mission St., Santa Cruz, CA 95060
Dixon Field Station, 800 Business Park Drive, Suite D, Dixon, CA 95620
Tel. 530-669-5097, Fax 707-678-5039, julie_yee@usgs.gov

Education

Ph.D., Statistics
University of California, Davis, 1997

Dissertation Title: Asymptotic Approximations to Bayesian Posterior Distributions in Survival Problems with Incomplete Data.

M.S., Statistics
University of California, Davis, 1993

Emphasis: biostatistics, survival analysis, linear model theory, simulation and resampling methods of data analysis, spatial statistics, nonparametric inference.

B.S., Mathematics
California Institute of Technology, 1991

Employment

Biology Statistician
United States Geological Survey, Western Ecological Research Center (WERC)
Aug 1997 – present

- Research and statistical computing collaboration to principal research scientists. Became principal investigator of WERC sea otter program in 2018.

Associate Instructor
UC Davis, Division of Statistics
Jan 1997 – Jun 1997

- "Statistical Analysis Through Computers," including the theory and application of probability, statistics, and computer simulation.

Recent Products

Stephenson, NL, AJ Das, NJ Ampersee, BM Bulaon, and JL Yee. In press. Which trees die during drought? The key role of insect host-tree selection. Journal of Ecology (doi: 10.1111/1365-2745.13176)

Zimmerman, GS, VW Varela, and JL Yee, 2019, Detection probabilities of bird carcasses along sandy beaches and marsh edges in the northern Gulf of Mexico. Environmental Monitoring and Assessment. In press.

Capitolo, PJ, HR Carter, JL Yee, GJ McChesney, MW Parker, RJ Young, RT Golightly, and WB Tyler, 2019, Changes in breeding population sizes of double-crested cormorants *Phalacrocorax Auritus* in the Humboldt Bay area, California, 1924-2017. Marine Ornithology. In press.

Hatfield, BB, JL Yee, MC Kenner, JA Tomoleoni, and MT Tinker, 2018, California sea otter (Enhydra lutris nereis) census results, spring 2018: U.S. Geological Survey Data Series 1097, 10 p., https://doi.org/10.3133/ds1097.

Fleskes, JP, AM Ramey, AB Reeves, JL Yee. 2017. Body mass, wing length, and condition of wintering ducks relative to hematozoa infection. Journal of Fish and Wildlife Management. doi: http://dx.doi.org/10.3996/082016-JFWM-063

Takekawa, JY, WM Perry, J Adams, Josh, JJ Felis, LL Williams, JL Yee, DL Orthmeyer, JW Mason, GJ McChesney, WR McIver, HR Carter, and RT Golightly, 2017. At-sea distribution and abundance of seabirds and marine mammals off southern California GIS resource database: Aerial seabird and marine mammal surveys off southern California, 1999–2002: U.S. Geological Survey data release, https://doi.org/10.5066/F7PK0D9P

Alpers, CN, JL Yee, JT Ackerman, JL Orlando, DG Slotton, and MC Marvin-DiPasquale, 2016, Prediction of fish and sediment mercury in streams using landscape variables and historical mining: Science of the Total Environment, v. 571 (15 November 2016), p. 364-379, DOI: 10.1016/j.scitotenv.2016.05.088. [First online 2 July 2016]

Fleskes, JP, JL Yee, GS Yarris, DL Loughman. 2016. Increased body mass of ducks wintering in California's Central Valley. Journal of Wildlife Management. doi: 10.1002/jwmg.1053

Ackerman, JT, CA Eagles-Smith, MP Herzog, JL Yee, CA Hartman. 2015. Egg laying sequence influences egg mercury concentrations and egg size in three bird species: Implications for contaminant monitoring programs. Environmental Toxicology and Chemistry. In press. doi: 10.1002/etc.3291

Berry, KH, AA Coble, JL Yee, JS Mack, WM Perry, KM Anderson, MB Brown. 2015. Distance to human populations influences epidemiology of respiratory disease in desert tortoises. The Journal of Wildlife Management 79(1):122–136. doi: 10.1002/jwmg.816

Meese, RJ, JL Yee, M Holyoak. 2015. Sampling to Estimate Population Size and Detect Trends in Tricolored Blackbirds. CVBC Bulletin 17(2-4):51-56.

Miles, AK, DH Van Vuren, DC Tsao, JL Yee. 2015. Experimental enhancement of pickleweed, Suisun Bay, California. California Fish and Game 101(2): 87-100.

Ackerman, JT, CA Hartman, MP Herzog, LM Smith, SM Moskal, SEW De La Cruz, JL Yee, and JY Takekawa, 2014, The critical role of islands for waterbird breeding and foraging habitat in managed ponds of the South Bay Salt Pond Restoration Project, South San Francisco Bay, California: U.S. Geological Survey Open-File Report 2014-1263, 108 p., http://dx.doi.org/10.3133/ofr20141263.

Berry, KH, LM Lyren, JL Yee, TY Bailey. 2014. Protection benefits desert tortoise (Gopherus agassizii) abundance: the influence of three management strategies on a threatened species. Herpetological Monographs 28(1): 66-92. doi: 10.1655/HERPMONOGRAPHS-D-14-00002

O'Neil, ST, JM Warren, JY Takekawa, SEW De La Cruz, KA Cutting, MW Parker, and JL Yee. 2014. Behavioural cues surpass habitat factors in explaining prebreeding resource selection by a migratory diving duck. Animal Behaviour 90: 21-29. doi: 10.1016/j.anbehav.2014.01.004

De La Cruz, SEW, JM Eadie, AK Miles, J Yee, KA Spragens, EC Palm, JY Takekawa. 2014. Resource selection and space use by sea ducks during the non-breeding season: Implications for habitat conservation planning in urbanized estuaries. Biological Conservation 169: 68-78. doi: 10.1016/j.biocon.2013.10.021

Curriculum Vitae

COLLEEN YOUNG
California Department of Fish and Wildlife, Office of Spill Prevention and Response
Marine Wildlife Veterinary Care and Research Center
151 McAllister Way, Santa Cruz, CA 95060
831.212.7010 (cell); 831.469.1740 (office); 831.469.1723 (fax)
colleen.young@wildlife.ca.gov

EDUCATION

Master of Science, Marine Science, Moss Landing Marine Laboratories, San José State University, December 2009
Bachelor of Science, Animal Biology, University of California, Davis, June 2006

RELEVANT EMPLOYMENT HISTORY

2011-present Environmental Scientist/Sea Otter Biologist, CA Dept of Fish and Wildlife, Office of Spill Prevention and Response, Santa Cruz, CA
2010-2011 Staff Research Associate II, UC Davis Wildlife Health Center/Marine Wildlife Veterinary Care and Research Center, Santa Cruz, CA
2010-2011 Scientific Aid, California Department of Fish and Game/Marine Wildlife Veterinary Care and Research Center, Santa Cruz, CA
2009-2011 Marine Mammal Observer, MLML/NOAA, central CA
2009-2010 Research Associate, Central CA Seabird Health Study, Moss Landing Marine Laboratories/Marine Wildlife Veterinary Care and Research Center, Santa Cruz, CA
2009-2010 Graduate Student Assistant, Teacher Enhancement Program, Moss Landing Marine Laboratories, Moss Landing, CA
2009-2010 Coordinator, Monterey County Marine Mammal Stranding Response Network, Moss Landing Marine Laboratories, Moss Landing, CA
2007-2009 Primary Investigator, Harbor Seal Disturbance Study, National Park Service, Glacier Bay, AK
2006-2007 Private Science Tutor, Sylvan Learning Center, Pacific Grove, CA
2005-2006 Peer Science Tutor, UC Davis, Davis, CA
2003-2004 Veterinary Student Technician, UC Davis Veterinary Medicine Teaching Hospital, Davis, CA

RESEARCH AND FIELD EXPERIENCE

Marine mammal, seabird and sea turtle capture, tagging, and biological sampling

- Sea otters: central CA (June 2010-present)
    - Wilson traps/rebreather diving, tangle nets, dip nets – flipper tags, TDRs, VHF transmitters, biological sampling
- Harbor seals: San Francisco Bay, CA (2007-2010), Glacier Bay, AK (2007)
    - Tangle nets, dip nets – flipper tags, satellite tags, VHF transmitters, biological sampling

- Common Murres: Monterey Bay, CA (2013)
    - Spotlighting – captured for dispersant study
- Marbled Murrelets: Ano Nuevo Bay, CA (2010)
    - Spotlighting – banding, biological sampling
- Rhinoceros Auklets: Ano Nuevo Island, CA (2011, 2012)
    - Mist netting – banding, biological sampling
- Green sea turtles: Baja California, MX (March 2007)
    - Tangle nets – flipper tags
- Leatherback sea turtles: central California (October 2007 & 2008)
    - Hoop net - suction cup tags, biological sampling

Stranded marine mammal response/carcass recovery
- Dead marine mammals
    - Sea otters: central CA (2010-present)
    - Cetaceans, pinnipeds: Monterey County, CA (2006-2010)
- Live marine mammals
    - Sea otters: central CA (2012-present)
    - Pinnipeds: Monterey County, CA (sporadically 2006-2010)

Marine vertebrate and elasmobranch necropsy
- Sea otters (2009-present)
- Cetaceans & pinnipeds (2007-2011)
- Seabirds (2007-2011)
- Sea turtles (sporadically and opportunistically 2007-present)
- White sharks (sporadically and opportunistically 2017-present)

Marine mammal and sea bird population/abundance monitoring
- Aerial
    - Sea otter census surveys, central CA (2010-present)
    - Marine mammal and leatherback turtle surveys, central CA (2009-2011)
- Land-based
    - Sea otter census surveys, central CA (2010-present)
    - Harbor seal monitoring study, Glacier Bay, AK (2007-2008)
- Vessel-based
    - Marine mammal, seabird, and leatherback turtle surveys, central CA (2008-2013)

Telemetry
- VHF radio tracking
    - Sea otters, central CA (2010-present)
    - Harbor seals, Glacier Bay, AK (2007)
    - Green sea turtles, Baja California, MX (2007)

Scientific diving and boating
- 100% O_2 Rebreather diving: sea otter captures (2010-present)

- Scientific diver
    - California Department of Fish and Wildlife (2010-present)
    - Monterey Bay Aquarium (2009-present)
    - Moss Landing Marine Labs (2006-2010)
    - UC Davis (2005-2006)
- Boating
    - CDFW boat handler (2010-present)
    - Deckhand/Divemaster on recreational dive boats, central CA (2006-2010)

Marine vertebrate behavioral observations
- Research participant: ongoing sea otter behavioral studies, central CA (2010-present)
- Principal investigator: harbor seal study (behavioral observations, energetic modeling) – Master's thesis, Glacier Bay, AK (2007-2009)
- Intern: juvenile dolphin behavior study (behavioral observations, boat driving, data entry) – Mote Marine Laboratory, Sarasota, FL (2005)

Thermography
- Research associate: seabird thermography study – using thermal imagery to assess thermal stability and waterproofing in captive and rehabilitated seabirds, central CA (2010-2011)

Other research experience and relevant skills
- Field technician/diver – Caribbean Wrasse specimen collection and gamete dissection, Florida Keys, FL (2005)
- Underwater acoustic receiver array deployment and retrieval – various MLML student thesis projects, central CA (2007-2009)
- Specimen collection of intertidal and subtidal kelp and invertebrates – various MLML student thesis projects, central CA (2007-2009)
- Theodolite operator – used to obtain bearings on vessels and seals in Glacier Bay, AK (2007-2008)
- Extensive data and database management experience, MS Excel and MS Access (2007-2011)
- ATV operator (2012-present)
- Beach driving (2011-present)

OIL SPILL PREPAREDNESS AND RESPONSE

Oil spill preparedness training
- 24-hr HAZWOPER (Nov 2010); last annual 8-hr refresher (Dec 2018)
- FEMA ICS-100, 200
- PRBO Wildlife Processing
- Environmental Response to Oil Spills training (2012)

- Annual table top and full deployment spill drills and annual floating sea otter pen deployment drills (2010-present)

Oil spill/algae event response experience

- Santa Cruz Mystery Spill – dead bird inventory (2007)
- Oregon Harmful Algal Bloom – live bird handling (2009)
- Refugio Oil Spill, Santa Barbara County, CA – wildlife reconnaissance, recovery, and transport (May 2015)

LIVE ANIMAL HANDLING AND REHABILITATION EXPERIENCE

• Seabird restraint, various species (alcids, grebes, loons, pelicans, etc.) – rehabilitation setting - International Bird Rescue, Cordelia, CA and Monterey SPCA Wildlife Center (sporadically 2009-present)
• Seabird restraint, various species (alcids, grebes, loons, pelicans, etc.) – field research and field recovery settings – central CA (2010-present)
• Sea otter restraint – field research setting – central CA (2010-present)
• Harbor seal restraint – field research setting – central CA (2007-2011)
• Domestic companion animal restraint – clinical setting – UC Davis VMTH, Davis, CA (2003-2004)

PUBLICATIONS

Young, C, Eguchi, T, Ames, JA, Staedler, M, Hatfield, BB, Harris, M, and Golson-Fisch, EA. 2018. Drift and beaching patterns of sea otter carcasses and car tire dummies. Marine Mammal Science, *in press*.

Young, C, Miller, MA, Kuchta, R, Brabec, J, Newsome, S, and Dailey, M. 2017. First report of an adult tapeworm (Cestoda: Diphyllobothriidea) in a southern sea otter (*Enhydra lutris nereis*). Journal of Wildlife Diseases, 53(4): 934-937.

Law, CJ, **Young, C**, and Mehta, RS. 2016. Ontogenetic scaling of theoretical bite force in southern sea otters (*Enhydra lutris nereis*). Physiological and Biochemical Zoology 89(5): 347-363.

Lieske, D, Vapniarsky, N, Verstraete, FJM, Leale, DM, **Young, C**, and Arzi, B. 2015. Characterization of the temporomandibular joint of southern sea otters (*Enhydra lutris nereis*). Frontiers in Veterinary Science. 2:71

Young, C, Gende, SM, and Harvey, JT. 2014. Effects of vessels on harbor seals in Glacier Bay National Park. Tourism in Marine Environment, 10(1-2): 5-20.

Hughes, SN, Tozzi, S, Harris, L, Harmsen, S, **Young, C**, Rask, J, Toy-Choutka, S, Clark, K, Cruickshank, M, Fennie, H, Kuo, J, and Trent JD. 2014. Interactions of marine mammals and birds with offshore membrane enclosures for growing algae (OMEGA). Aquatic Biosystems, 10:3

Harris, L, Tozzi, S, Wiley, P, **Young, C**, Richardson, TMJ, Clark, K, and Trent, JD. 2013. Potential impact of biofouling on the photobioreactors of the Offshore Membrane Enclosures for Growing Algae (OMEGA) system. Bioresource Technology, 144: 420-428.

Young, C, Gende, SM, and Harvey, JT. 2010. Disturbance of harbor seals by vessels in Johns Hopkins Inlet. Alaska Park Science, 9(2): 57-59.

Young, C. 2009. Disturbance of harbor seals by vessels in Johns Hopkins Inlet, Glacier Bay, AK. Master's Thesis, San Jose State University/Moss Landing Marine Laboratories, 112 p.

DISTINCTIONS/HONORS

• CDFW Employee Excellence Award for "Partnership" (2018)
• CDFW Employee Excellence Award for "Vision" (2014)
• Dean's Honors List, College of Agricultural & Environmental Sciences (UC Davis: fall 2002-spring 2005, spring 2006)
• Student leadership award (UC Davis, 2002-2003)

VOLUNTEER WORK/PUBLIC OUTREACH

• Volunteer diver, Monterey Bay Aquarium (2009-present)
• BeachCOMBERS volunteer (2006-present)
• Marine Mammal Stranding Network volunteer, Moss Landing Marine Laboratories (2006-2009)
• Moss Landing Marine Laboratories Annual Open House Volunteer (2006-2009)

ADDITIONAL CERTIFICATIONS/TRAINING

• NAUI Basic SCUBA Diver – 06/2004
• NAUI Advanced SCUBA Diver – 06/2005
• NAUI Divemaster – 06/2006
• AAUS Research diver – 06/2005
• NAUI Enriched air/Nitrox diver – 06/2005
• NAUI Drysuit diver – 06/2007
• DAN First Aid, CPR, O_2 Administration, and AED – renewed 10/2018
• DAN Emergency Management Provider – renewed 10/2018
  - o Advanced O2 First Aid for SCUBA Diving Injuries
  - o Neurological Assessment for Divers
• Water survival/helicopter underwater egress training – renewed 01/2017
• Wire strike avoidance – 08/2016
• Wilderness First Aid – 09/2016
• Swiftwater rescue – 06/2018
• Motorboat Operator Training Course - June 2017
• Department of Boating and Waterways, California Boating Safety – renewed 06/2018
• Small boats operator, MLML - 2008
• ATV operator training – 04/2012

U.S. Geological Survey Western Ecological Research Center (WERC) Animal Care and Use Committee (ACUC) Approval Form

Project Title: Population Dynamics and Biology of Sea Otters

Principal Investigator: Julie Yee

Date of ACUC Application Submission: 11/20/18

Veterinary Reviewer: Dr. Bill Van Bonn

Date of Veterinarian Review: 12/18/18

As the veterinary reviewer, I hereby certify that with my knowledge and expertise, I have reviewed the document herein for appropriateness of the species and the number of animals proposed; the drugs and dosages used; methods of animal restraint, captivity, and transportation (if applicable); diet supplementation; any surgical and non-surgical procedures or experiments performed on the animals including equipment used; monitoring and management of discomfort, distress, or pain to animals; euthanasia methods; and any exemptions from standards of care, if requested that necessarily cause pain or distress to the animal(s) under study without the use of anesthetics, analgesics, or tranquilizing drugs, and that all of my review comments have been satisfactorily addressed.

Veterinary Signature: ______________ Date: 1 Feb 19

WERC ACUC Chair: Sarah Spring

As the Animal Care and Use Committee Chair, I hereby certify that the Animal Care and Use application has been reviewed by the Western Ecological Research Center Animal Care and Use Committee for completion and that less stringent comments were addressed prior to forwarding the application to the veterinarian for review. Following veterinarian review the Animal Care and Use application herein has been approved by the Western Ecological Research Center Animal Care and Use Committee.

ACUC Chair
Approval Signature: ______________ Date: 2/6/2019

This ACUC is valid for the duration of the project or 5 years after date of final approval, whichever comes first.

This ACUC is set to Expire on ______________

-- WERC ACUC PROTOCOL -- Instructions

1. Answer every question in **blue ink**. Do not leave any answer spaces blank. If a question is not applicable, answer the question by explaining briefly why the question is not applicable. Upon completion, email the final copy and all of the requested supporting documentation to WERC Animal Care and Use Committee (ACUC) Chair, Sarah Spring (sarah_spring@usgs.gov) and send a carbon copy (Cc) to Shamara Gough (sgough@usgs.gov), WERC ACUC Committee Member.

NOTE: To mark any boxes, double click and select "checked" as default value.

2. If you rely on the scientific literature or on any of the following reference standards to explain or justify an answer, identify the reference:

- ILAR Guide to the Care and Use of Laboratory Animals
- American Society of Mammalogists Animal Care and Use Guidelines
- Ornithological Council Guidelines to the Use of Wild Birds in Research
- American Fisheries Society, American Institute of Fishery Research Biologists, and American Society of Ichthyologists and Herpetologists Guidelines to the Use of Fishes in Research
- American Society of Ichthyologists and Herpetologists Guidelines to the Use of Amphibians and Reptiles in Research

3. If you are working with collaborators and the protocol has already been reviewed by an ACUC at another institution, provide a copy of that protocol and the response by the ACUC, including questions or comments, and your answers to Sarah Spring (sarah_spring@usgs.gov) and Shamara Gough (sgough@usgs.gov) for review **prior** to completing this form.

4. Audiovisual material (e.g., sound files, photographs, maps, and/or video footage) of your field work may help the ACUC to understand your proposed research methods and techniques, but it is not required. If you have created an audiovisual record, please consider submitting it to the ACUC. If you submit such material, include descriptive captions for all photographs; i.e. what action is taking place, how, and why.

Audiovisual material is submitted in accompaniment to this form:

☐ YES

☒ NO

NOTE: It is unlawful to begin work until all federal or state permits required for your research have been issued. An ACUC may choose to request that you provide copies of your permits for the administrative record.

Two different laws – the Animal Welfare Act (AWA) and the Health Research Extension Act of 1985 are applicable to wildlife research. The Interagency Research Animal Committee (IRAC) published *U.S. Government Principles for the Utilization and Care of Vertebrate Animals Used in Testing, Research, and Training* extending AWA coverage to all vertebrates when work is conducted by Federal Researchers. This document also requires that, "the transportation, care, and use of animals should be in accordance with the Animal Welfare Act **and other** applicable Federal laws, guidelines, and policies." Therefore, guidelines from the Health Research Extension Act of 1985, as well as Public Health Service (PHS) Policy implemented by the National Institutes of Health (NIH) Office of Laboratory Animal Welfare (OLAW), are extended to all research involving live vertebrate animals. The ACUC will reference all of the above mentioned guidelines (and others) for review of this submitted protocol.

PRELIMINARY QUESTIONS

1. Does your research entail the study of live vertebrates?

☒ YES

☐ NO

Note: A study that entails the eggs and embryos of vertebrates are not covered until those eggs hatch. However, the larval forms of fish and amphibians are covered.

If the answer to Question 1 is NO, STOP here. Your research does not require ACUC approval. Please proceed to Section X-B.

If the answer to Question 1 is YES, proceed to answer Question 2.

2. If your research is to be conducted in the field, does the research involve invasive procedures, or will it harm or materially alter the behavior of an animal under study?

☒ YES

☐ NO

Note: Any study that includes capture, handling, and marking of live vertebrates is subject to initial review. The ACUC will determine whether or not the project is a ***field study*** *defined as a study conducted on free living wild animals in their natural habitat that does not involve invasive procedure or materially alter the behavior of the animal/species under study. If so, field studies are exempt from ACUC approval. The term "invasive procedure" is not defined by the Animal Welfare Act nor PHS policy. However, the Animal Welfare Act defines a "major operative procedure" as any surgical intervention that* ***penetrates and exposes a body cavity*** *or any procedure which produces permanent impairment of physical or physiological functions. For the purposes of completing this form, use the phrase "penetrates and exposes a body cavity," to mean invasive. OLAW defines "minor survival surgery" as one that does not expose a body cavity and causes little or no physical impairment. It is up to ACUC to determine if any operative procedure is minor and if it is invasive.*

If the answer to Question 2 is YES, then skip a-c and complete the rest of this form.

If the answer to Question 2 is NO, answer a-c, read the additional information, and proceed to Section X-C.

a) provide your name, phone number, and e-mail address.

Name: Click or tap here to enter text.

Phone: Click or tap here to enter text.

Email: Click or tap here to enter text.

b) briefly describe the nature of the research procedures and what measures you will take to assure that these procedures will not alter or influence the activity of the animals. For instance, if you plan to take photos, will you use a blind or other camouflage? Will you use a long lens so as to increase your distance from the animal?

Click or tap here to enter text.

c) describe where the studies will be located, what procedures will be involved, and the nature of the habitat where you will be working.

Click or tap here to enter text.

The ACUC will determine if further review is needed. If so, you will be asked to supply the additional information requested on this form. If not, you will receive email confirmation from the ACUC stating that your study qualifies as a 'field study,' is exempt from further ACUC review, and you may proceed with your research, subject to these two provisions:

1. You must notify us if a significant change to the project occurs. With regard to the "field study exemption," a change will be considered significant if the changes include an invasive procedure, or that harm the animal or materially alters the behavior of an animal under study or that alter or influence the behavior or the animal.

2. It is unlawful to begin work until all federal or state permits required for your research have been issued. An ACUC may choose to request copies of your permits for the administrative record.

Project title: Population Dynamics and Biology of Sea Otters

Umbrella study plan title (if applicable): Population Biology of Sea Otters in the Northeast Pacific

Approximate start date: 15 Dec 2018

Planned completion date: 15 Dec 2023

Principal investigator: Julie Yee

Permanent phone number: 916-284-7713

Field site phone number (if available):

E-mail address: Julie_yee@usgs.gov

If the PI will not be on site during the entire project, identify the individual or individuals who will be responsible for supervising the on-site work. Give the name, a contact phone number and e-mail address where that individual can be reached when the research is actively underway. This person must be able to assume responsibility for decisions and/or actions necessary to ensure animal health and welfare and the health and safety of all field workers. If this alternate cannot be contacted, the ACUC will assume responsibility and take actions deemed necessary to ensure appropriate animal care.

Alternate Supervisor Contact Information		
Name and Title	**Field Site Phone Number**	**E-mail Address**
Joe Tomoleoni - Wildlife Biologist	831-254-9750	jtomoleoni@usgs.gov
Brian Hatfield – Wildlife Biologist	805-305-2121	brian_hatfield@usgs.gov
Michael Kenner – UC Santa Cruz Marine Tech	831-254-5184	mkenner@usgs.gov, mkenner@ucsc.edu

-- Personnel qualifications --

Please provide a brief description of the following:

a) Method of training for all field personnel on the proper care and use of wild animals.

Only qualified veterinarians will perform transmitter implant surgery on sea otters. Veterinarians inexperienced in the procedure will first observe the surgery performed by an experienced veterinarian before performing the procedure him/herself. Only experienced personnel will directly participate in the capture and handling of sea otters. Less-experienced personnel will initially assist with other aspects of fieldwork (i.e. field observations and data collection) and when time allows will be trained by one or more of the experienced researchers in this study in the appropriate tasks of animal capture handling (first by watching experienced personnel conducting the technique, then by performing the technique under close supervision).

b) Person responsible for providing training and their qualifications.
Veterinarians and vet assistants will be trained by Dr. Mike Murray, senior vet of the Monterey Bay Aquarium's sea otter program. Dr. Murray has over 25 years of experience with sea otter medicine and has implanted hundreds with instruments over the years. Non-veterinary otter handlers and transporters will be trained and overseen by wildlife biologists Joe Tomoleoni and Brian Hatfield. Between them, they have over 40 years of experience observing, capturing and handling sea otters.

c) How employee performance will be evaluated on techniques including but not limited to capturing, handling, marking, physical examinations of animals, injection of harmless substances, blood sampling, non-major surgeries, and euthanasia.

Employee performance is constantly being evaluated by supervisors or more experienced personnel. If performance is sub-par, corrective action is taken by instructing the employee on the proper technique, or removing the employee from that particular role.

d) For the PI and co-PI, and anyone who will act in a supervisory role in the field, please complete the table below.

Name	Title	Experience/Qualifications
Joe Tomoleoni	Wildlife Biologist	10 years' experience observing, capturing and handling sea otters
Brian Hatfield	Wildlife Biologist	34 years' experience observing, capturing and handling sea otters
Michael Kenner	UCSC – Marine Tech	31 years' experience observing, capturing and handling sea otters

SECTION I: PROJECT DESCRIPTION, GENERALLY

PURPOSE OF STUDY

a) Describe the specific objectives of your study. Try to use terms and language that could be understood by a non-scientist.

Our overall goal in CA is to study the population status of endangered sea otters, which is a keystone species (in other words, without which the nearshore ocean ecosystem would be dramatically altered), in order to provide scientific information to management agencies and federal partners that they can consider when making decisions to positively affect the recovery of the southern sea otter population and improve ecosystem health. In order to achieve this goal our research will address these specific objectives: Document patterns of mortality in the sea otter population, including spatial and temporal trends in the cause of death, and compare to equivalent patterns detectable from beach-cast carcasses. Collect basic data on sea otter demography, health and behavior required to refine, update and further develop population models used for advising federal and state management agencies. Examine the inter-relationships between nutritional requirements, energetic expenditure, anthropogenic and environmental stressors, individual health and population performance.

b) Explain how the study will benefit wildlife, humans, or society. Benefits can include basic scientific knowledge; conservation and/or management applications for wildlife; wildlife habitat; wildlife or human health.

Sea otters are a keystone species. In other words, without them, the nearshore ecosystem would be dramatically altered. Sea otters benefit ocean kelp forests which nourish fish and other sea life important to wildlife health and human economic interests. Sea otters provide this benefit by acting as a main predator on sea urchins, which are capable of decimating kelp forests, as has been widely observed by scientists. Our work will contribute to basic scientific knowledge of sea otter individuals and populations as well as provide management agencies with tools for smarter, more effective goals and regulations.

c) Justify:

Rationale for the study of live animals: why must animals be studied rather than using computer models, habitat studies, etc.?)

Appropriateness of species to be studied

- Describe the biological characteristics of the animal species that make them suitable for this particular study. Cost should not be used as a justification, except as a means to choose among species that are equally suitable.
- Please explain how this work will benefit this particular species or other species that share its habitat or, if you are studying this species as a surrogate, how this species will serve as a model for the other species of interest.

Number of animals to be studied

- How did you determine the number of animals to be studied?

- When possible, include a statistical power justification of the sample size or yield of tissue per animal.
- For complex studies, providing a flow chart or table showing group size, time frame, study locations, and other information may be helpful in explaining how the total number of animals was determined.

***Rationale for the study of live animals*:**
In order to study the population health, demography, behavior and ecology of wild sea otters in their natural environment, there are no alternatives to the use of live animals. Any alternatives to the use of live animals, or more specifically the use of wild sea otters, would not achieve the research goals (to understand population dynamics, demographics, habitat use, health profiles and energetic constraints in free-living sea otters).

Appropriateness of species to be studied:
The research objectives of this project are specifically directed at understanding sea otter populations in California and addressing conservation questions about this species; no other animal species would be appropriate for this goal. Additionally, the sea otter represents an optimal sentinel (or indicator) of coastal ecosystem health, due to their sensitivity to pathogen and chemical pollution, their near-shore distribution, their extraordinary appeal to the general public (a fact which generates community support for monitoring efforts), and their tractability for observational study.

Number of animals to be studied:
A review of both the published results of past studies (citations below) and of our own unpublished data sets has provided us with fairly strong knowledge about the variation in data we can anticipate on population vital rates (e.g. survival, reproduction), behavior (e.g. diet and home range use) and individual health parameters (e.g. seroprevalence for various pathogens, tissue contaminant loads, etc.). Highly variable data can lead to statistically imprecise population-level estimates, but their precision can typically be improved by increasing the numbers of individuals in the population being sampled. Based on anticipated variances, we have proposed the minimum sample sizes sufficient (when combined with our existing samples) to obtain statistically informative results from the various analytical procedures we will conduct to achieve our objectives. Over the next 5 years we will capture up to 600 animals for flipper tagging and bio-sampling, in order to characterize basic measures of population health. Of these, we will apply surgically-implanted transmitters and bio-logging time-depth recorders (TDRs) to up to 300 animals, which will be used for analyses of behavior, diet, survival rates, reproduction, spatial contrasts of mortality patterns, and spatially-explicit, multifactorial epidemiological models. The total population size of the southern sea otter at present a minimum of 3,128 individuals, based on our most recent survey data. Our request to capture, tag, and bio-sample 600 animals over three years, assuming it is spread out as up to 120 animals per year, therefore represents less than 3.8% of the current total population each year. Our request to surgically-implant transmitters and TDRs applies to half this number, or less than 1.9%.

We do not present power analyses for practical reasons. While power analyses can be very useful for assessing the adequacy of a sample, in general power analyses require a greater deal of analyses than the actual data analysis itself. Proper power analyses consist of results of a range of hypothetical analyses, each with the same statistical complexity as the actual analysis, except for different hypothetical sample sizes. Although some simple power formulas exist, these are special cases that only apply to simple data analyses (e.g. analyzing the significance of a single mean or a difference of two means). General power analyses often require intensive computer simulations in order to evaluate how the outcome of analyses can change in correspondence to different sample sizes.

As a comparison, our proposed sample sizes are slightly less than the sample sizes for a recent ACUC with the University Santa Cruz, for a similar sea otter research program (400 animals across 3 years, or approximately 133 animals per year, representing approximately 4.2% of the total population at that time).

Citations of papers that provide estimates of sea otter vital rates and associated variances:

Eberhardt, L. L. 1995. Using the Lotka-Leslie model for sea otters. Journal of Wildlife Management 59:222-227.

Eberhardt, L. L., and K. B. Schneider. 1994. Estimating sea otter reproductive rates. Marine Mammal Science 10:31-37.

Gerber, L. R., T. Tinker, D. Doak, and J. Estes. 2004. Mortality sensitivity in life-stage simulation analysis: A case study of southern sea otters. Ecological Applications 14:1554–1565.

Jameson, R. J., and A. M. Johnson. 1993. Reproductive characteristics of female sea otters. Marine Mammal Science 9:156-167.

Riedman, M. L., and J. A. Estes. 1990. The sea otter, Enhydra lutris: behavior, ecology and natural history. U S Fish and Wildlife Service Biological Report 90:I-III, 1-126.

Riedman, M. L., J. A. Estes, M. M. Staedler, A. A. Giles, and D. R. Carlson. 1994. Breeding patterns and reproductive success of California sea otters. Journal of Wildlife Management 58:391-399.

Siniff, D. B., and K. Ralls. 1991. Reproduction, survival and tag loss in California sea otters. Marine Mammal Science 7:211-229.

Tinker, M. T., D. F. Doak, and J. A. Estes. 2008. Using demography and movement behavior to predict range expansion of the southern sea otter. Ecological Applications 18:1781-1794.

Tinker, M. T., D. F. Doak, J. A. Estes, B. B. Hatfield, M. M. Staedler, and J. L. Bodkin. 2006. Incorporating diverse data and realistic complexity into demographic estimation procedures for sea otters. Ecological Applications 16:2293-2312.

Tinker, M. T., J. Tomoleoni, N. LaRoche, L. Bowen, A. K. Miles, M. Murray, M. Staedler, and Z. Randell. 2017. Southern sea otter range expansion and habitat use in the Santa Barbara Channel, California. US Geological Survey Open File Report 2017-1001:76p.

ANIMAL SPECIES (Scientific and Common Name)	Number to be studied (Year 1)	Number to be studied (Year 2)	Number to be studied (Year 3)	Number to be studied (Year 4)	Number to be studied (Year 5)
Southern Sea Otter – *Enhydra lutris nereis*	120	120	120	120	120
*** NON-TARGET ANIMALS (Scientific and Common Name)**	**Potential Number Affected (Year 1)**	**Potential Number Affected (Year 2)**	**Potential Number Affected (Year 3)**	**Potential Number Affected (Year 4)**	**Potential Number Affected (Year 5)**
Sea Otter – *Enhydra lutris*	100	100	100	100	100

* **NON-TARGET ANIMALS** *include any non-study animals directly or indirectly affected by the research. Examples include the potential to live-capture or kill non-target individuals (e.g., loss of offspring due to taking of one or both parents) or disturb/harass other species during the research activity.*
NOTE: Species lists might include general descriptors such as "all native mammals" rather than an extensive list of individual species.

PERMITS: Identify all required permits or other forms of written authorization including protected species permits at the national and state or provincial levels (in the U.S.: Migratory Bird Treaty Act, Endangered Species Act, CITES, Marine Mammal Protection Act, and Wild Bird Conservation Act; Lacey Act; state permits for state-listed species); national and state/provincial protected areas permits (in the U.S., National Wildlife Refuge System, National Parks, National Forest System, Bureau of Land Management; state permits for wildlife management areas, parks, or other protected areas). If the study will take place on private land please provide documentation of landowners permission.

Permit type or other form or written authorization	Permit number, if any	Expiration date (or if application or renewal application pending, date submitted)
US Fish and Wildlife, scientific research on marine mammal	Renewal of #MA672624-20	Submitted 8/10/2018

If your research requires federal or state permits, it is unlawful to begin work until all permits have been obtained. You may not start the work for which permits are required until the permits are issued, even if your protocol has been approved.

VETERINARY INVOLVEMENT

If your research entails a major procedure [As defined by the Guide to the Care and Use of Laboratory Animals (similar to AWA "major operative procedure defined above): "As a general guideline, major survival surgery (e.g., laparotomy, thoracotomy, joint replacement, and limb amputation) penetrates and exposes a body cavity, produces substantial impairment of physical or physiologic functions, or involves extensive tissue dissection or transection (Brown *et al*., 1993). Minor survival surgery does not expose a body cavity and causes little or no physical impairment; this category includes wound suturing, peripheral vessel cannulation, percutaneous biopsy, routine agricultural animal procedures such as castration, and most procedures routinely done on an "outpatient" basis in veterinary clinical practice."] or the use of controlled substances, detail the involvement of a veterinarian in the planning of the procedure(s). Will the veterinarian collaborate with you in carrying out the procedure(s)? If so, provide name, contact information, affiliation, and details of involvement.

Note: *Section 5 of the model Veterinary Practices Act endorsed by the American Veterinary Medical Association (AVMA) states that, "No person may practice veterinary medicine in the State except within the context of a veterinarian-client-patient relationship [VCPR] and that a VCPR cannot be established solely by telephonic or other electronic means." Be sure to define the method of interaction during the planning, collaboration, and advising stages of the project.*

Name: Dr. Mike Murray

Phone: 831-238-6924

Email: mmurray@mbayaq.org

Affiliation: Monterey Bay Aquarium

Details: Dr. Murray is a Senior Veterinarian with whom the project has benefitted from frequent in-person discussions and interactions. Dr. Murray is involved in all aspects of animal care, including pre-deployment planning as well as captures, deployment, and, when applicable, operative and post-operative care. During pre-deployment, when field operations are planned, Dr. Murray assumes responsibilities for contacting the various facilities capable of holding sea otters. As a best practice for prudence, he gives them a heads up when there is an outside chance we may be calling on them for assistance.

SECTION II: MAINTAINING WILDLIFE IN CAPTIVITY

TEMPORARY ANIMAL HOUSING

Will animals will be held in captivity temporarily but:

a) for more than 12 hours? (Animal Welfare Act)

YES NO

☐ ☒

b) overnight?

YES NO

☐ ☒

If you answered YES to either of the two questions, describe:

- *the planned duration of the captivity*
- *the temporary holding facilities you intend to use, specifying cage size/type:*
- *equipment that you intend to use;*
- *feeding strategies;*
- *plans for maintaining suitable environmental conditions, and*
- *release procedures.*
- *A photograph, drawing, or illustration of the holding facility may help to clarify your description.*

Description: Animals will not be held in captivity for more than 12 hours or overnight, unless a veterinarian determines the animal has a need for medical intervention requiring a longer stay. If necessary, distressed animals will be transferred to the nearest marine mammal rehabilitation or holding facility with sea otter holding capabilities, such as Monterey Bay Aquarium, California Department of Fish & Wildlife Marine Wildlife Veterinary Care & Research Center, The Marine Mammal Center, Aquarium of the Pacific, or Sea World San Diego. Transport, holding, and care protocols will be in accordance with the facility's standard operating procedures.

PERMANENT ANIMAL HOUSING

If animals are to be held permanently, describe:

- *duration of quarantine and diagnostic testing;*
- *acclimatization to captivity and the presence of researchers and lab techs;*
- *housing facilities including cage size/type;*
- *sanitation procedures;*
- *social grouping or solitary housing and the reasons for such housing;*
- *health monitoring procedures;*
- *list any ACUC approved SOPs to be followed for housing or husbandry.*

Description: NA

ANIMAL DIET

List food type (if applicable) and describe:

- *Feed and water method*
- *Frequency that the animal will be fed*
- *If food items or quantities other than the animal's natural diets will be used, please also answer "***SECTION III-DIET SUPPLEMENTATION OR ALTERATION.***"*

Description: NA

SECTION III: PROCEDURES OTHER THAN SURGERY

If you are planning activities not listed below, please describe all procedures under the section entitled **"OTHER."**

YES NO

☒ ☐ **WILDLIFE CAPTURE (LIVE CAPTURE OR KILL TRAPPING)**

Describe

- *equipment to be used;*
- *planned duration of trapping/restraint;*
- *monitoring protocol/schedule for traps;*
- *how you will treat capture myopathy;*
- *potential for trapping non-target species;*
- *disposition of trapped animals; and*
- *if anesthesia or immobilization is planned please complete those sections of this form.*

Capture Techniques:

Individual sea otters will be captured either in tangle nets, underwater diver-held traps (Wilson traps), or hand-held dip nets. All methods are routinely used throughout the range of the sea otter population (U.S., Russia, and Canada). Recapture of individuals will most likely be by underwater diver-held traps.

Diver-operated Wilson Traps

Our primary capture method involves using diver-operated traps to capture resting sea otters. Shore spotters with high-powered spotting scopes relay information about target animals to the dive crew. Divers work in pairs and each diver has a trap with a capacity for one adult sea otter, 2 juveniles, or a mother/pup pair. Otters must be resting (preferably sleeping) for this method to be successful. Divers use closed-circuit oxygen rebreathers and electric propulsion vehicles to maneuver the traps underneath the floating sea otters and engulf them with a net bag, which is closed by a purse line. The divers keep the animal and trap on the surface until the transport vessel arrives and the otters can be transferred to a sliding-lid capture box. Our research group has captured >600 sea otters in California, and >1000 sea otters in California, Alaska, Washington, Canada, and Russia combined, using diver operated Wilson traps with no trap-related mortalities. This method is highly selective, with zero chance for taking non-target species. Furthermore, this method allows us to target specific individuals, minimizing disturbance or harassment to non-target individuals.

Tangle Nets

Tangle nets are surface floating, un-weighted nets set in near shore waters in the vicinity of sea otters. Nets are typically 100 m long by 5 m deep (stretch mesh of about 22 cm), but may be modified to capture in shallow water. Each tangle net consists of stretch mesh hung between a positively-buoyant float line and a slightly negatively buoyant led line, and are suspended between large float buoys at each end which are anchored in place (ensuring sufficient anchor-line scope to avoid dragging the buoys below the surface under any tide or current condition). Nets are set out by a tending skiff and then monitored by the skiff and/or shore-based observers. When one or more otters become entangled in the net, the skiff returns and extracts the otter(s), transferring them to capture boxes for transport to the processing site. The deployment of nets is made under due consideration of predicted weather conditions: nets will not be set during periods of weather or sea state that may preclude their tending. In an effort to minimize the chances of entanglements or by-catch of non-target species: 1) two shore-based observers with telescopes (instead of just one) will monitor a deployed net, with one observer continuously scanning the float line of the net in order to detect entanglements, and the second observer scanning the entire vicinity around the net for any marine mammal activity.

Dip Nets

Dip-netting is a procedure where sea otters are dipped out of the water with a large fish-landing net. Open-water capture takes place from the bow of a small skiff, with one net handler and a vessel operator. This method is usually used to capture young animals. USGS personnel have been involved in the capture of >250 sea otters using dip-nets with no dip-net-related mortalities. There is virtually no potential for bycatch with this technique.

YES	NO	
☒	☐	**ANIMAL TRANSPORTATION**

Describe

- *how animals will be transported from a capture location to a field camp or processing site or facility and returned; and*
- *if an animal (live or dead) is to be transported from the field, describe measures to be taken to avoid potential disease transmission to researchers and other animals.*

Description: The processing facility will generally be on a boat or a shore-based facility easily accessible by boat. Transport of animals from capture sites will therefore usually be by small boat and animals will be transported in an "otter box" as described below. In some instances, transport by vehicle may be preferable when reduced transit time or calmer conditions may be achieved. In this case, the animal in the otter box will be transported in an air-conditioned vehicle. "Otter Boxes" are rinsed and/or hosed clean between uses. Dead animals are not transported in the boxes. There is no precedence for transmission of disease from live sea otters to other animals or humans other than the possibility of infection from a puncture bite, however, standard surgical protocols – mask, goggles and nitrile gloves – are used during veterinary procedures.

YES	NO	
☒	☐	**PHYSICAL RESTRAINT FOLLOWING CAPTURE**

Describe

- *method(s) to be used;*
- *planned duration of restraint;*
- *equipment to be used, including dimensions of equipment if applicable;*
- *observation schedule during confinement;*
- *Provide detailed justification and protocol if animals are to be physically restrained for longer than 1 hour at a time.*

Description: Holding:

The sea otters are transferred directly from the Wilson Trap, Tangle Net, or Dip Net, to a specially designed "otter box." These boxes have been customized over many decades of sea otter capture and handling, and represent the best possible temporary holding container for sea otters. Box materials, dimensions, and accessories have been designed and approved by both sea otter biologists and sea otter veterinarians with decades of experience in handling and transporting wild sea otters.

The boxes are made of marine grade plywood with an epoxy coating to protect the otters and the box itself. The epoxy also creates a smooth surface on the interior, and makes the boxes easy to clean. Wood is a desirable material because it is strong and sturdy, but still soft enough that the most uncooperative otters can chew it without damaging their teeth. The interior dimensions of the boxes are 36"L x 17"W x 22"H, providing more than enough room for an adult male sea otter, or a female and large pup. The box features a sliding plywood lid. By design, the walls and lid create a dark interior, which is believed by veterinarians and animal care experts, to have a calming effect on the animals inside. Our decades of field experience with these boxes have shown that the otters appear to be very calm once inside the box.

All 4 sides, and the bottom panel of the box feature 5/8" holes drilled at multiple levels for adequate ventilation. These holes serve another purpose though. The box may be floated in the ocean, alongside the boat, at any time. The holes allow water to enter the box, so that the otter can float inside the box. The cold seawater helps the otter thermoregulate, and helps to prevent any overheating that might potentially occur as a physiological response to the capture process.

Inside the box, a "false bottom" is installed. This is a PVC grate that allows refuse or materials such as feces to pass through the grate and exit via the bottom of the box, eliminating any chance of the material fouling the otter's fur. This keeps the interior of the box clean and tidy. Boxes also have canine "chew toys" (the kind you get at your local pet store) installed for the otters that like to chew. Chewing on a chew toy decreases the likelihood of the otters chewing on the wood box, while also giving them a distraction and reduces their anxiety while inside the box.

When otters need to be physically restrained (e.g. when being injected with the sedative) the procedure is done so in the safety of the otter box. A "stuff sack," which is a very soft cushion similar to a pillow but covered with a tough cordura exterior, is used to gently block the otter's head and shoulders while the vet administers the injection into the hindquarters. The process only takes a few seconds, and the otter usually uses the stuff sack as a chew toy.

Holding time:

Captured individuals will be transported from the capture location to the handling location in holding boxes that provide adequate ventilation. Ice or cold water will be provided as needed to keep the animals cool. Transport time will be kept to a minimum by co-locating capture vessels and handling/processing platforms. All animals will be released at or as near to their location of capture as is possible. Efforts will be made to process and release sea otters within 2 hrs of capture. The otters are not physically restrained for this entire time. Most of the time is spent in the safety and relative comfort of the otter box, or anesthetized. Animals are typically checked approximately every 15 minutes when inside the otter box.

YES NO

☒ ☐ **EQUIPMENT DECONTAMINATION PROCEDURES**

Describe

- *where appropriate, the decontamination procedures for equipment that will be used to capture, transport, contain, etc. animals; and*
- *frequency of decontamination.*

Description: "Otter Boxes" are rinsed and/or hosed clean between uses. Dead animals are not transported in the boxes. There is no precedence for transmission of disease from live sea otters to other animals or humans via equipment.

YES NO

☒ ☐ **PERSONAL PROTECTIVE EQUIPMENT (PPE)**

Describe all PPE that will be used by personnel including, gloves, respirators, goggles or faceshields, etc. If no PPE is planned, explain the likelihood of exposure to potential hazards (pathogens – including mode of transmission; bites, scratches, and stings), the potential consequences, and any other methods you intend to use to avoid the hazards or the consequences, such as physical means, prophylactic medicines, post-exposure treatment.

Description: Field crews will typically only use "stuff sacks" described above in conjunction with the "otter box" to safely contain animals. Elbow length leather gloves may be worn to aid with handling for sedation. Vet crew wear standard surgical PPE – goggles, mask and nitrile gloves.

YES NO

☒ ☐ **MONITORING THE HEALTH OF CAPTURED ANIMALS**

Describe

- *observations planned for monitoring health of captured animals*
- *physiological parameters (e.g., temperature, pulse rate, respiration rate, capillary refill time) to be recorded;*
- *frequency of measurements;*
- *expected normal ranges for all physiological parameters monitored; and*
- *provide a protocol for addressing physiological parameters outside of normal ranges (e.g., how do you plan to treat hypothermia?).*

Description: Observations planned for monitoring health of captured animals: Animals are initially evaluated by field teams at the site of capture. Divers and boat tenders are all experienced sea otter biologists and are capable of recognizing overt anomalies in animal health. Should any be noticed, veterinarians at the shore/boat based veterinary care area are notified. Based on findings, a decision is made to either release the animal or continue transport to the vet facility. Sea otters are aggressive, dangerous carnivores and therefore thorough examination of an awake sea otter is not feasible; only the most apparent overt signs of abnormality are noted. Once sedated, the sea otter is subjected to a thorough physical examination by an experienced veterinarian. If practical, abnormalities are addressed. Beyond physical exams, clinical pathology parameters, such as blood glucose, blood gases, and limited hematological values are evaluated.
Physiological parameters (e.g., temperature, pulse rate, respiration rate, capillary refill time) to be recorded: Throughout the time period during which the sea otter is chemically immobilized, the following physical parameters are monitored: rectal temperature, pulse rate, respiratory rate, hemoglobin saturation (via pulse oximetry).
Frequency of measurements: Measurements are taken and recorded at a minimum of every 5 minutes, more frequently if directed by the attending veterinarian.
Expected normal ranges for all physiological parameters monitored: Temperature: 99-101 F; Pulse rate: 120-160 beats/min; Resp rate: 12-20 breaths/min; Hemoglobin saturation: 95-100%
Protocol for addressing physiological parameters outside of normal ranges: Hypothermia is rarely encountered in sea otters. When observed it is often associated with hypoglycemia. If low body temperature is noted, all cooling agents, such as ice, will be removed. Vigorous drying/rubbing of the skin and fur will occur. Inspired gas may be warmed; the otter placed on towels or blankets, and pre-warmed fluids administered as indicated. Hyperthermia is much more common in the sea otter. Attempts to prevent elevated body temperature start with the capture team. Unless the otter's transport is very short (this parameter is determined by factors such as otter activity, apparent body weight, struggling during capture, ambient temperature and sun exposure), the otter will be maintained in the water within the capture box for 10-15 minutes prior to transfer to the vet lab. If noted while immobilized, ice bags will be placed on the inguinal areas, ventral cervical, axillary space, and on the breathing tubes to cool inspired air. If these steps are unsuccessful, cold water enemas may be administered. Efforts to manage core body temperature start before the animal becomes hyperthermic; typically ice is placed on the inguinal area once temperature exceeds 100 F. Bradycardia (slow heart rate) will be managed as indicated by the veterinarian. Drugs, such as atropine may be administered as needed. Tachycardia (rapid heart rate) is also managed by the veterinarian. In most cases, this state is the result of inadequate sedation. It may be managed with increased drug doses and/or decreased external stimulation (ie, reduction of noise, ear muffs, covering the eyes). Decreased respiratory rate is also managed by the veterinarian. The most common method to manage this finding is to intubate the trachea and provide intermittent positive pressure ventilation. Rarely, chemotherapeutics such as doxapram may be indicated. Tachypnea, like tachycardia, is generally the result of inadequate sedation, and will be managed accordingly. Either states, increased heart or respiratory rates may also be managed by the addition of inhalant anesthetics, such as isoflurane. In the rare case in which an otter becomes markedly unstable and efforts to stabilize are unsuccessful, doses of naltrexone and flumazenil can be administered to reverse the effects of the sedative.

YES	NO	
☒	☐	**MARKING OR TAGGING**

Describe

- *marker type and why that particular type is to be used;*
- *mass of the device as a proportion of body mass;*

- *recommended device mass proportionate to body mass;*
- *method and mass of attachment method;*
- *expected effect, if any, on behavior, health, or social status of an individual.*

Description: Flipper Tags: Generally, all animals captured > 11 lbs (> 5.0 kg) will be visually tagged to prevent repeated sampling of the same individuals. Temple tags, used on the hind flippers, are 45 x 14 x 2 mm, and weigh ~7g (0.14% of body mass for the smallest otters). Each otter will be tagged with unique color/number (typically 2 tags per otter [1 per flipper], no more than 4 tags [2 on each flipper]). Because long-term tag retention rates are <100% (Ames et al. 1982, 1983) each sea otter may also be marked with a coded, passive transponder chip, implanted subcutaneously in the inner thigh. When flipper-tagging, holes are punched using a sterile leather punch (hole diameter <5mm). Flipper tags have been used extensively in sea otter research and rehabilitation effort without any observed deleterious effects. In addition, we request the ability to use newer electronic "smart" flipper tags in addition to, or in place of 1 or more of, the traditional Temple Tags described above. The smart flipper tags will be of comparable size and weight, but are still being developed and tested. These smart tags will have GPS capability, as well as network capability, allowing them to "talk" to the tags on other otters, thereby collecting, storing, and increasing opportunities for relaying information to a base station when in range. They are solar-powered and may include other additional sensors like an accelerometer, wet/dry switch, etc. These tags are being developed in a collaboration between USGS and NASA. Concurrent to tag development, different materials and form factors are being tested on captive sea otters at the Monterey Bay Aquarium. These smart tags will be capable of collecting geo-location data and/or conducting otter-shore or otter-otter communications, and we anticipate that eventually they will replace the implantable VHF transmitters as a less-invasive, primary means of sea otter tracking/monitoring. The form-factor and attachment method are similar to the temple tags, and these next-generation smart tags would only be deployed on wild otters (in addition to, or in place of, temple tags) after they have been tested and evaluated by a USDA-licensed research facility under the approval of the institution's IACUC. These experimental instruments will not be deployed on free-ranging sea otters unless the IACUC agrees that no significant negative effects were noted.
PIT Tags: Implantation of "passive integrated transponders", or PIT tags, may be done to facilitate identification in the event of external tag loss. PIT tags have been safely used in multiple species of all sizes, including sea otters, without deleterious effects to survival. 125 MHz tags, approximately 13 x 2mm, will be injected into the left inguinal area using a 12 gauge needle and syringe. Tag, needle, and syringe are gas-sterilized together in a package or come pre-sterilized from the manufacturer (Biomark, Boise, ID). PIT tags are encased in biocompatible glass, which protects the electronics while preventing adverse effects to the animal. All captured otters will be scanned prior to initiation of sampling/external tagging for identification and to access prior capture history.
VHF Radio Transmitters & Archival Time-Depth Recorders (TDRs): For some aspects of our research, use of electronic signaling tags is necessary. VHF radio transmitters (80 x 22 x 50mm, ~160g, Advanced Telemetry Systems, Isanti, MN) and time depth recorders (TDRs, 67 x 17 x 17mm, ~27g, Wildlife Computers, Redmond, WA) are standard instruments that are currently surgically implanted in sea otters. Radios are potted in a waterproof electrical resin and coated with a USP Class VI material (United States Pharmacopeia, Class VI requires the most stringent testing). TDRs are potted in a hydrolytically stable material and coated with a non-bioreactive coating. Instruments are gas-sterilized and sealed in surgical steri-peal pouches for storage until used. This procedure has been successfully completed on several hundred sea otters in Alaska and California with very low rates of mortality (< 0.2%). Together, both instruments will represent between 0.5% (in a large male) to 2% (in a 10 kg juvenile) of body weight.

YES NO

☒ ☐ **BLOOD SAMPLING**

Describe

- *needle gauge and length;*
- *collection site preparation;*
- *location of collection sites;*
- *sample volume;*
- *frequency of sampling(s);*
- *total samples per animal;*
- *how long an animal is retained for sampling; and*
- *indicate the percent blood loss per sample based on the animal's body mass, how fluid volume will be restored, and describe how animal(s) will be monitored for anemia.*

Description: 1.) If large samples are needed (eg >12 ml?), the best site to sample is the jugular vein. The simplest way to locate the jugular vein is to draw a straight line between the thoracic inlet and the corner of the mandible: The jugular vein runs just under the skin between these two points. The vessel may be difficult to visualize in otters with poor peripheral perfusion due to low blood pressure or in normal adult male otters due to their robust, muscular necks. In many cases, moistening the fur overlying the vein with a judicious amount of rubbing alcohol will aid in visualization.

2.) If smaller samples are required, the popliteal vein can be used along with physical immobilization. This vessel is best accessed from the medial aspect of the stifle joint. With the femur at a right angle to the pelvis and the tibia at a right angle to the femur, the phlebotomist grasps the proximal tibia placing the tip of the thumb over the medial tibial condyle and the remainder of the thumb along the long axis of the tibia. An appropriately sized needle (19 ga x 1.5" for an adult sea otter) is inserted (attached to syringe) perpendicular to the skin just medial and distal to the sesamoid bone in the medial head of the gastrocnemius muscle. When the thumb and otter's limb is properly positioned, the insertion point is at about the 10:00 or 2:00 position for the left and right legs respectively. In most cases the needle is advanced nearly to its complete length under slight negative pressure and then withdrawn slowly until the vessel is entered. The syringe should fill rapidly; a slow fill time indicates entry into one of the smaller vessels nearby. If fill time is delayed too much, clotting of the sample is likely. It is important to maintain digital pressure over the phlebotomy site for 2-4 minutes after withdrawing the needle to prevent hematoma formation. The most important aspect of the process is firm, resolute restraint in a consistent, reproducible orientations, as vascular access is totally blind.

3.) A third sample site is the anterior vena cava. This location is especially useful for obtaining blood samples from juvenile & neonate otters with small blood vessels. This technique is associated with increased risk due to the location of the vessel within the thoracic cavity making direct pressure hemostasis impossible. Properly performed, however, this approach provides a good blood sample from otherwise problematic individuals. As with other sampling methods, consistent positioning and good restraint are critically important. The anterior vena cava is best approached with the otter in sternal recumbency, restrained like a cat for jugular venipuncture. The front legs are extended and held off the edge of the table. The head is held firmly and extended with the nose point upward. The otter's body is pinned by the elbow to the restrainer's body. Using a 22-25 ga x 1.5" needle attached to a 1-6 ml syringe (patient size dependent), the thoracic cavity is entered at the junction of the sternum and the first rib. When approaching from the left side, the needle is directed towards the right elbow. If the approach is from the right side, the needle is directed parallel to the sternum. Immediately upon perforating the skin, a slight negative pressure is placed on the syringe. It is not unusual to locate the vessel as the needle is withdrawn. Slow, deliberate movements watching carefully for the "flash" of blood in the needle's hub increase success rates.

Samples are taken at the time of initial capture or recapture. Sampling will never occur more often than at 3-

month intervals. In practice, most recaptures are annual, or even less frequent. Blood is drawn via venipuncture, from the jugular vein. Isopropyl alcohol is used to clean the site and aid in the identification of the vessel. Animals are typically retained for no more than 2 hours, and every effort is made not to exceed this duration of holding time. Total sample may be up to 5% of blood volume, which is estimated to be 8% of body weight.

YES NO

☒ ☐ **URINE/FECES SAMPLING**

If your method requires capture and holding of the animal, indicate the planned duration and method of holding.

Description: Urine may be collected via free catch, catheterization, or cystocentesis and feces via free-catch, manually collected per rectum, or opportunistically during processing but animals will not be held just for these collections.

YES NO

☒ ☐ **OTHER BODY FLUIDS AND TISSUE SAMPLING**

Indicate

- *the type of substance, e.g. hair, feathers, scales, muscle tissue, abdominal fluid, swabs, bone marrow;*
- *method of collection;*
- *volumes per sample; frequency of sampling(s);*
- *length of time animal is held for sampling; and*
- *total samples per animal.*

Description: In addition to blood, urine and feces collections described above, other samples to be collected include microbiological cultures from nasal, rectal, oral and/or vaginal swabs, and three vibrissae, to be used for diet analysis via measurement of stable isotope ratios (vibrissae are readily extracted with a quick outward-tug). In the case of animals captured for telemetry instrumentation, a vestigial upper premolar will be extracted for age determination using standard dental elevators and forceps (Siniff and Ralls, 1988). Plugs of skin and tissue from flipper-tag punches will be retained for DNA testing and measurement of tissue contaminant levels. Milk samples will be collected opportunistically from lactating females using standardized techniques developed for marine mammals: prior to milk collection, an intra-muscular dose of oxytocin (1.0 ml of 20 IU/ml solution) will be administered, and the area around the mammary gland will be cleaned thoroughly using distilled water and dried with a clean towel. Having modified a large gauge syringe by cutting off the tapered end, the open mouth of the syringe will be placed over the nipple and, by drawing back the plunger, milk will be expressed and collected: we will attempt to collect a minimum of 1 ml and a maximum of 20 ml from each lactating female. As with all sampling and instrumentation, every effort will be made not to hold animals more than 2 hours.

YES NO

☒ ☐ **BEHAVIORAL OR OBSERVATIONAL STUDY (WITHOUT SIGNIFICANT RESTRAINT OR NOXIOUS STIMULI)**

Describe

- *procedure including frequency, duration of each observational session;*
- *number of observers;*

- *distance from animals; and*
- *type of equipment to be used.*

Description: Monitoring of study animals by radio telemetry and direct observation is non-invasive, and causes no distress to the subjects. The researchers will regularly cover the study area, by vehicle and/or by boat, in order to gather resights (i.e. new sample survey information on a previously sampled animal) of all tagged and instrumented otters: the primary purpose of this procedure is to monitor the survival, reproductive status and movement of study animals. Observers typically work singly or in pairs and remain 50 to several hundred meters from the study animal. A resight will consist of determining an otter's location by triangulation from the transmitter signal and, if possible, by making a visual sighting. Radio instrumented otters are to be located using programmable scanning receivers (Advanced Telemetry Systems, Isanti, MN), and identified using binoculars and high powered spotting scopes (Questar Corp., New Hope, PA). When an otter is located, the researcher will record its exact position as GPS coordinates. Other data recorded at each resight will include number of other otters with the subject animal, reproductive status (i.e. whether or not females have pups), behavioral state, presence or absence of a kelp canopy, water depth and distance from shore. A resight for each study animal will be obtained every 2-3 days, weather permitting. Researchers will also collect data on diet and foraging behavior by direct observation of feeding otters. In this procedure, the study animal is located (as described above) and observed using a Questar spotting scope (at 50x or 80x magnification). The data to be collected include the duration of each dive and subsequent surface time; whether or not the dive was successful; prey type; number and size of prey items caught; prey handling time, and various other information (as described in the documentation for the USGS-WERC sea otter database). Foraging data will be collected from all instrumented study animals on an opportunistic basis, although every attempt will be made to obtain roughly equivalent quantities of data from each animal, and particularly from animals with an active (i.e. data-collecting) TDR.

Data on activity budgets of study animals will be obtained by recording the behavior of a focal animal at 10 minute intervals over a 24 hour period: details of this method are provided elsewhere (Ralls and Siniff, 1990). Behavior will be recorded following the templates provided in the documentation for the USGS-WERC sea otter database.

YES NO

☐ ☒ **BEHAVIORAL OR OBSERVATIONAL STUDY (WITH SIGNIFICANT RESTRAINT OR NOXIOUS STIMULI)**

Describe

- *restraint procedure;*
- *equipment;*
- *duration;*
- *frequency;*
- *type of noxious stimulus;*
- *methods used to monitor animals for pain or distress*
- *methods to minimize pain or distress, if any; and*
- *scientific justification for the degree of restraint and/or noxious stimuli.*

Description: NA

YES NO

☐ ☒ **DIET SUPPLEMENTATION OR ALTERATION**

If food items or quantities other than the animal's natural diets will be used, describe

- *diet items and quantities;*
- *purpose for dietary change;*
- *planned duration;*
- *anticipated nutritional deficit/adverse effect;*
- *weight monitoring of animal(s);*
- *amount of weight gain or loss that will be allowed; and*
- *monitoring protocol/schedule for effects;*
- *planned diet for animal's whose natural diet is live prey. For these cases. How will the adequacy of diets other than live prey be assessed?.*

Description: Captive stay is brief (typically < 2 hours) so food and water are not provided.

YES NO

☒ ☐ **FOOD AND/OR WATER DEPRIVATION**

If food or water will be restricted or withheld, describe

- *duration of restriction or deprivation;*
- *frequency of deprivation;*
- *reason(s) for deprivation;*
- *monitoring protocol of animal(s);*
- *amount of weight loss that will be allowed;*
- *anticipated deficit/adverse effect; and*
- *monitoring protocol/schedule for effects*

Description: Captive stay is brief (typically < 2 hours) so no food and water are provided.

YES NO

☐ ☒ **INDWELLING CATHETERS OR IMPLANTS**

Describe

- *type;*
- *size;*
- *duration of use;*
- *maintenance and monitoring protocol/schedule; and*
- *if implantation requires a surgical protocol please complete Section VIII*

Description: NA

YES NO

☐ ☒ **ADMINISTRATION OF PARALYTICS (OTHER THAN IN THE COURSE OF SURGERY)**

Describe

- *agent;*
- *dose (mg/kg);*
- *route of administration;*
- *frequency of administration;*
- *duration of paralysis; and*
- *if used in conjunction with a procedure(s) involving potential pain, how will the presence of pain, depth of anesthesia, degree of analgesia be assessed?*

Description: NA

YES NO

☐ ☒ **ADMINISTRATION OF ANESTHETICS (OTHER THAN IN THE COURSE OF SURGERY)**

Describe

- *agent;*
- *dose (mg/kg);*
- *route of administration (manufacturer & model of equipment);*
- *duration of anesthesia;*
- *method of monitoring anesthesia;*
- *maintenance/monitoring procedures to ensure normal body temperature is maintained in the animal;*
- *procedures to be used in case of anesthetic emergency over-dose;*
- *monitoring protocol to ensure animal's complete recovery from anesthesia; and*
- *if by inhalation, the method of scavenging waste anesthetic gas/fumes; or*
- *if injectable agent(s) are not commercially prepared and sterility guaranteed please describe method used to assure the agent's sterility when injected.*

Description: NA

YES NO

☐ ☒ **ADMINISTRATION OF ANALGESICS (FOR OTHER THAN POST-SURGICAL PAIN RELIEF)**

Describe

- *agent;*
- *dose (in mg/kg);*
- *route of administration; and*
- *frequency, and duration of use.*

Description: NA

Yes No

☒ ☐ **USE OF CONTROLLED AND/OR PRESCRIPTION SUBSTANCES**

Irrespective of source, describe

- *source of substances;*
- *record keeping;*
- *storage; and*
- *precautions taken to avoid unauthorized access.*

Description: Source of substances: Controlled drugs are obtained from Central Avenue Pharmacy, Pacific Grove, CA.
Record keeping: Records are maintained in accordance with regulations established by the federal Drug Enforcement Agency, California Board of Veterinary Examiners, and California Board of Pharmacy. Records are maintained by both permit holder and the DEA license holder.
Storage: Controlled substances are stored in accordance with regulations. They are maintained under lock and key (maintained by attending veterinarian). As indicated, Class 5 safe is used to store controlled drugs.
Precautions taken to avoid unauthorized access: Only licensed veterinarians, veterinary technicians, and veterinary assistants have access to controlled drugs. Inventory is maintained and monitored by DEA license holder. All controlled drugs are maintained under lock and key by the DEA license holder.

YES NO

☐ ☒ **ADMINISTRATION OF DRUGS, TOXINS, REAGENTS, CELLS, ETC. (OTHER THAN ANALGESICS, ANESTHETICS, OR PARALYTICS)**

Describe

- *agent;*
- *dose (mg/kg);*
- *diluent;*
- *route of administration;*
- *equipment to be used for administration;*
- *frequency of administration;*
- *length of time animal maintained under influence;*
- *anticipated deficit/adverse effect, if any;*
- *monitoring protocol/schedule for effects;*
- *monitoring procedures to ensure cell lines have been screened for rodent pathogens; and*
- *if injectable agent(s) or silastic implant(s) are not commercially prepared and sterility guaranteed, describe method used to assure the agent's sterility when injected.*

Description: NA

YES NO

☐ ☒ **SURVIVAL SURGERY (MINOR)**

If YES, complete ***SECTION VIII Animal Surgery Information****.*

YES NO

☒ ☐ **SURVIVAL SURGERY (MAJOR, SINGLE)**

*If YES, complete **SECTION VIII Animal Surgery Information**. A major operative procedure is one that enters a body cavity. (For example, implanting a telemetry device into the body cavity constitutes a major operative procedure).*

YES NO

☒ ☐ **SURVIVAL SURGERIES (MAJOR, MULTIPLE)**

*If YES, complete **SECTION VIII Animal Surgery Information**. You must provide additional justification to perform multiple major operative procedures on one animal. Removal of telemetry devices is an acceptable reason.*

YES NO

☐ ☒ **NON-SURVIVAL SURGERY** *If YES, complete **SECTION VIII Animal Surgery Information**.*

YES NO

☐ ☒ **DEATH AS AN ENDPOINT**

- *If the protocol involves observing or studying the animal until death occurs you must provide scientific justification as to why an earlier endpoint is not acceptable in **Section IV, Alternatives to Procedures that Cause Pain or Distress**.*
- *If collecting the animal by shooting, lethal trapping or other means, describe the method of euthanasia or humane killing to be used in **Section VII, Euthanasia and Human Killing**.*

YES NO

☐ ☒ **OTHER**

Describe any other procedure to be administered not previously addressed.

Description: NA

SECTION IV: ALTERNATIVES TO PROCEDURES THAT CAUSE PAIN OR DISTRESS

The Interagency Research Animal Committee (IRAC), Animal Welfare Act (AWA) and its implementing regulations, and the Public Health Service Policy (PHS) ALL require that the principal investigator consider alternatives to procedures that may cause more than a momentary or slight pain or distress to the animal. The term "distress" is not defined in any of the resources above, however, the IRAC's *U.S. Government Principles for the Utilization and Care of Vertebrate Animals Used in Testing, Research, and Training* states that, "Unless the contrary is established, investigators should consider that procedures that cause pain or distress in human beings may cause pain or distress in other animals."

In the ILAR Guide to the Care and Use of Laboratory Animals (2011), the term distress is defined as "…an aversive state in which an animal fails to cope or adjust to various stressors with which it is presented….[although it] …may not induce an immediate and observable pathologic or behavioral alteration …" For the purpose of completing this table, please use this definition. You may also refer to Attachment A for category descriptions and examples.

Complete this table based on anticipated levels of pain and distress for your procedures.

	APHIS CATEGORY C NO PAIN, DISTRESS, OR THE USE OF PAINRELIEVING DRUGS	APHIS CATEGORY D TEACHING, RESEARCH, SURGERY, OR TESTS INVOLVING PAIN OR DISTRESS FOR WHICH APPROPRIATE ANESTHETIC, ANALGESIC, OR TRANQULIZING DRUGS WILL BE USED	APHIS CATEGORY E TEACHING, EXPERIMENTS, RESEARCH, SURGERY, OR TESTS INVOLVING PAIN OR DISTRESS FOR WHICH THE USE OF APPROPRIATE ANESTHETIC, ANALGESIC, OR TRANQUILIZING DRUGS WOULD ADVERSELY AFFECT THE PROCEDURES, RESULTS, OR INTERPRETATION OF THE TEACHING, RESEARCH, EXPERIMENTS, SURGERY, OR TESTS.
EXPECTED PRIOR TO PROCEDURE	☐	☐	☐
EXPECTED DURING PROCEDURE	☐	☒	☐
EXPECTED POST PROCEDURE	☐	☐	☐

Note: For all procedures you must describe any measures you will take to alleviate pain/distress as a part of your detailed description (if applicable).

Please provide a detailed description of all methods that may cause pain or distress (even momentary) to the animal under study and sources consulted to determine that alternative procedures are either not available or not acceptable.

For any method that may cause more than momentary or slight pain or distress to the animals, include in the description the effort made to identify and evaluate alternatives to these methods.

Note: If no published literature or sources are available, the researcher may describe discussions with other researchers with relevant experience and/or your own, unpublished observations. If the answer relies in whole or in part on discussions with other researchers, consider providing contact information for these individuals as the ACUC may wish to consult with one or more of them.

Description: The methods determined to be CLASS D procedures include the surgical implantation of VHF transmitters and time-depth recorders, biopsy sampling (during surgery) and the extraction of a vestigial premolar tooth for age estimation. See Section VIII - Surgical Procedure for full details of these methods. No feasible alternatives to the capture, immobilization and surgical implantation of telemetry instrumentation, or to age estimation via tooth sectioning and cementum analysis, have yet been developed for sea otters, based on our own expertise and on a review of the literature. Note: the details of the literature search results, and a full citation list of all relevant papers found, is attached to the end of this application.

Literature search

To satisfy the alternatives requirement, or in other words that no other alternative procedures to relieve pain or distress were acceptable, a literature search is required.

The Animal Welfare Act regulations suggest the use of the USDA National Agricultural Library's Animal Welfare Information Center, which has a compilation of databases [https://www.nal.usda.gov/publications]. However, these dozens of databases include many that are not useful for searching for alternatives and most are useful only for biomedical research. Do not feel constrained to use this particular resource; any relevant source is acceptable. The taxon-specific guidelines, for instance, include hundreds of species-specific references.

- American Society of Mammalogists Animal Care and Use Guidelines
- Ornithological Council Guidelines to the Use of Wild Birds in Research
- American Fisheries Society, American Institute of Fishery Research Biologists, and American Society of Ichthyologists and Herpetologists Guidelines to the Use of Fishes in Research
- American Society of Ichthyologists and Herpetologists Guidelines to the Use of Amphibians and Reptiles in Research

Describe your search strategy by:

- Identifying the sources of information or databases used
- The date or dates of your search
- Your key words
- Summarize the search results

Description: Sources: BIOSIS and Web of Science
Date of Search: 30 October, 2018
Key Words: Sea Otter - anesthesia, Sea otter - immobilization, Sea otter - neuroleptanalgesia

Relevant Results:

Arnemo, JM, P Dypsund, et al. (1997). "Surgical implantation of radio transmitters in wolverines." Norsk Veterinaertidsskrift **109(2): 103-104.**

Kollias, GV, N Abou-Madi (2014) "Procyonids and Mustelids" **In** Zoo Animal and Wildlife Immobilization and Anesthesia, 2nd Edition, Editor(s): G West, D Heard, N Caulkett. Pgs: **607-617**

Monson, DH, C McCormick, and BE Ballachey (2001). "Chemical anesthesia of northern sea otters (Enhydra lutris): Results of past field studies." Journal of Zoo and Wildlife Medicine **32(2): 181-189.**

Silveira, L, MM Furtado, et al. (2011) "Tagging Giant Otters (Pteronura brasiliensis) (Carnivora, Mustelidae) for Radio-Telemetry Studies" Aquatic Mammals **37(2): 208-212.**

Williams, TD., Sawyer, DC. (1996). "Chemical restraint and anesthesia of sea otters affected by the oil spill in Prince William Sound, Alaska." Journal of the American Veterinary Medical Association **208(11): 1831-1834.**

Williams, TD, AL Williams and DB Siniff (1981). "Fentanyl and Azaperone produced neuroleptanalgesia in the sea otter Enhydra lutris." Journal of Wildlife Diseases **17(3): 337-342.**

SECTION V: TYPE, FREQUENCY, AND TREATMENT OF INJURIES

Describe the most likely forms of injuries to research animals, how frequent an injury (ies) is (are) expected to occur, and planned procedures to treat injuries. **Even if you do not intend or expect to injure an animal, you must describe potential injuries and expected methods of treatment(s).**

Description: Historically, the most common injuries to captured sea otters were broken teeth due to biting down on exposed metal such as on a trap or kennel door. We have eliminated most such exposed surfaces – covering Wilson trap frames with plastic tubing and replacing kennels with wooden boxes. Our experienced field personnel are also aware of the potential problem and actively discourage biting of hard surfaces by use of soft stuff sacks and by providing chew toys in the transport boxes. There is little that can be done for such injuries beyond prevention but they are not life threatening nor terribly debilitating. Many wild sea otters have broken teeth and are not obviously impaired.

SECTION VI. WHAT WILL HAPPEN TO THE ANIMALS AT THE END OF THE RESEARCH?

a) If you plan to release animals, describe the pre-release conditioning, the site and time (date and time of day) of release, and any permits required for such release. NOTE: the release of captive animals that is not a planned part of a manipulative study requires justification. PIs are directed to consult taxon-specific guidelines regarding precautions for the release of captive individuals.

- American Society of Mammalogists Animal Care and Use Guidelines
- Ornithological Council Guidelines to the Use of Wild Birds in Research
- American Fisheries Society, American Institute of Fishery Research Biologists, and American Society of Ichthyologists and Herpetologists Guidelines to the Use of Fishes in Research
- American Society of Ichthyologists and Herpetologists Guidelines to the Use of Amphibians and Reptiles in Research

Description: Subject animals will be released immediately after processing – generally within 2 hours of capture.

b) If you plan to retain the animals for future research, when will you submit a protocol for the next research activity? Briefly describe that planned research activity.

Description: NA

c) If you plan to donate the animals to a zoo, captive-breeding program, or other arrangement entailing continued captivity, please describe the place where the animals to which the animals will be donated. Has this institution or organization agreed to accept the animals?

Description: NA

d) If you plan to euthanize the animals, describe the method of euthanasia to be used in the **Section VII, Euthanasia and Humane Killing**.

Note: In some instances, the landowner or federal agency (such as the National Park Service) may retain ownership of animals, specimens, or samples. In such cases, consult with the landowner or agency as to disposition.

SECTION VII: EUTHANASIA and HUMANE KILLING

The American Veterinary Medical Association (AVMA) published its revised *Guidelines for the Euthanasia of Animals* in 2013. As of September 1, 2013, OLAW required full implementation of the AVMA guidelines. Methods of euthanasia must comply with the AVMA guidelines unless the ACUC has approved a deviation. Deviations must be scientifically justified. Such a request for deviation is consistent with the AVMA guidelines which recognize that ending the life of wild animals in field settings might more appropriately be considered humane killing than euthanasia (AVMA pg. 81). Although the AVMA guidelines expressly do not apply to humane killing, methods considered acceptable therein are also acceptable and preferred for humane killing where possible. Under PHS Policy (section C.1.g), the ACUC has the authority to approve killing techniques not recognized as forms of euthanasia by the AVMA. Examples of other methods used for euthanasia or humane killing include those approved by the American Society of Mammalogists, the Ornithological Council, and the American Society of Ichthyologists and Herpetologists.

Whether euthanasia or humane killing, it is expected that investigators will use the most humane technique(s) feasible that is also consistent with study objectives.

Even if you do not intend to end animals' lives at any point in your project, a method of euthanasia or humane killing **must be listed** in cases of emergency except in instances where permits or statutes prohibit the killing of individuals of the species involved. If euthanasia or humane killing is prohibited by law or by permit conditions, provide supporting documentation.

YES	NO	
☒	☐	Does the project involve planned (or an emergency plan) euthanasia?
		If yes, which reference guidelines are used?

☐ AVMA (Specify revision year) ______________

☒ Other (Specify) American Association of Zoo Veterinarians

Describe the method of euthanasia.

Description: Euthanasia is not proposed or expected for this research. In the event that emergency euthanasia becomes necessary, euthanasia will be conducted by a qualified veterinarian following the protocol outlined below. Any euthanized animals, or tagged animals that die in the wild and are retrieved, will be necropsied as part of the ongoing pathology program at the CDFW and UC Davis (for which separate IACUC protocols exist).Euthanasia will only be considered in cases of immediate relief of irreversible pain and suffering from which return to the wild is considered inhumane. Other options, including therapeutic intervention and transfer to an authorized rehabilitation facility capable of managing sea otters (ie, Monterey Bay Aquarium Sea Otter Program) will be considered prior to euthanasia. Authorization for euthanasia must be obtained from both the attending veterinarian and the permit holder. As a result of the relatively precarious status of most sea otter populations, pre-euthanasia planning must include the collection of a variety of ante-mortem biologic samples, such as blood, urine, and potentially other tissues associated with research oversight committee-approved requests for biological samples. Additionally, preparations should be made to integrate the carcass into the necropsy database being developed under the leadership of the Marine Wildlife Veterinary Care and Research Center (MWVCRC) in Santa Cruz, CA (831-469-1719). The use of a consistent and thorough necropsy procedure results in the collection of a consistent sample set, which can then be compared to data from other sea otters. In order to safely and humanely euthanize a sea otter, some form of chemical restraint is recommended. This immobilization facilitates the collection of appropriate biological specimens, such as blood and urine antemortem. A combination of fentanyl citrate (0.22 – 0.33 mg/kg) and midazolam or diazepam (0.07 –0.11 mg/kg) administered intramuscularly will typically result in appropriate immobilization at the lower dose and actual anesthesia at the higher dose within 10 minutes of administration. These compounds are both controlled substances, and therefore must be handled, stored, and administered in accordance with provisions of state and federal law. After the injection is administered, the sea otter may be transferred into a kennel, capture box, or left within the net basket until sedated. Once the otter is adequately sedated, it may be placed in dorsal recumbency for access to the vascular system for euthanasia. After ante mortem sampling has been completed, the sea otter may be euthanized with a commercially available euthanasia solution containing sodium pentobarbital (a controlled substance and managed in accordance with state and federal law) given at a rate of 1.0 ml per 2-5 kg body weight, but typically not less than 3.0 ml. In most cases, the compound is administered intravenously via the jugular veins that are easily identified on the ventro-lateral aspect of the neck between the angle of the jaw and the thoracic inlet. A wetting agent, such as isopropyl alcohol, will aid in the identification of the vessel. Under some circumstances, direct intra-cardiac administration of euthanasia solution is preferable. Typical of the mustelids, the heart is located in the caudal aspect of the thoracic cavity, just cranial to the manubrium. As the sea otter's thorax is dorso-ventrally compressed, an apical heartbeat is generally easily visualized in the dorsally recumbent animal. An appropriately-sized needle, typically 22-20 ga 1.5-2.0 inch, may then be inserted between the ribs on either side just cranial to the site of the apical heart beat. Aspiration will confirm entry into one of the cardiac chambers, and the euthanasia solution is to be administered slowly. If no blood is recovered upon aspiration, the needle should be repositioned to assure entry into a cardiac chamber. It should be noted that the chemical characteristics of the euthanasia might render the heart difficult to assess during necropsy when the solution is administered via intra-cardiac route. The very dense pelage of the sea otter is a very effective insulator, and as such cooling of sea otter carcasses to slow autolysis may be problematic. Bodies should be protected within appropriately sized plastic bags and immediately immersed in iced water or they may be placed in a freezer for 2-3 hours to accelerate cooling. Once core body temperature has reached an appropriate level, typical refrigeration is adequate.

References

1. Guidelines for Euthanasia of Nondomestic Animals. American Association of Zoo Veterinarians, 2006.
2. Guidelines for Zoo and Aquarium Veterinary Medical Programs and Veterinary Facilities. American Association of Zoo Veterinarians, 1999.
3. Burns RB, McMahan W: Euthanasia methods for ectothermic vertebrates. In: Bonagura J (ed). Current Veterinary Therapy XII. WB Saunders Co, Philadelphia, PA, 1995, 1379-1381.
4. Reilly JS. Euthanasia of animals used for scientific purposes. "Australian and New Zealand Council for the Care of Animals in Research and Teaching.", 2nd ed, 2001: 85-86

YES	NO	
☐	☒	Does the project involve planned (or an emergency plan) humane killing?

If yes, please list the reference guidelines used and describe the method of humane killing.

Description: Click or tap here to enter text.

Describe the method used to ensure the animal will not revive and method of disposal of remains.

Description: Click or tap here to enter text.

YES	NO	
☐	☒	Is euthanasia or humane killing prohibited by law or by permit conditions?

If yes, please attach supporting documentation with this ACUC.

SECTION VIII: ANIMAL SURGERY INFORMATION

The term "surgery" is not defined in PHS Policy or the Animal Welfare Act regulations. The latter defines the term "major operative procedure" as any surgical intervention that penetrates and exposes a body cavity or any procedure which produces permanent impairment of physical or physiological functions. There is no definition of minor operative procedure; presumably, it is any procedure that does not penetrate or expose a body cavity or that does not produce permanent impairment of physical or physiological functions.

For the purposes of wildlife research, it is important to recall that the field studies exemption does not pertain to studies that involve "an invasive procedure, harms, or materially alters the behavior of an animal under study." The term "invasive procedure" is not defined in the Animal Welfare Act regulations. It is not clear if a minor operative procedure is considered invasive. However, OLAW recognizes the authority of the ACUC to determine whether specific manipulations used in research are major operative procedures and, given that neither OLAW nor APHIS has defined invasive procedure, it is reasonable to conclude that both agencies extend the authority to ACUCs to define invasiveness. The ACUC's determination must be based on a detailed description of the procedure and the anticipated or actual consequences, as characterized by the investigator. In some cases, the classification by the ACUC of a procedure as major or minor may be readjusted post-procedurally depending on clinical outcome. If the ACUC, after thorough review, determines that the surgical procedure only penetrates but does not expose a body cavity and that the procedure does not produce substantial impairment, the ACUC may conclude that it is not a major operative procedure. Any laparoscopic surgery that produces substantial impairment of physical or physiological function must be considered a major operative procedure. Whether the laparoscopic procedure is classified as major or minor, the ACUC must ensure that the appropriate analgesia, sterile technique, and perioperative monitoring is employed.

☐ Check here if no surgery is planned.

ANIMAL SPECIES (Scientific and Common Name)	Number that will be subjected to surgical procedure	S = Survival N = Non-survival	Surgery Location (Anatomic)
Southern Sea Otter – *Enhydra lutris nereis*	300	S	Abdominal cavity

PRE-OPERATIVE PROCEDURES AND CARE

a) Have obviously unhealthy or compromised animals been exempted from surgery?

Yes ☒ No ☐

If no, explain the rationale for performing surgery on obviously unhealthy or compromised animals.

Description: NA

b) Identify the individual responsible for evaluating pre-operative health status of animals.

Name: Dr. Mike Murray

Phone: 831-238-6924

Email: mmurray@mbayaq.org

Affiliation: Monterey Bay Aquarium

c) Provide a brief description of all pre-operative procedures and care.

Include

- *withholding of food and water;*
- *pre-operative antibiotic/therapeutic drug/fluid administration (agent, dose in mg/kg);*
- *route of administration, frequency, duration of treatment; and*
- *preparation of surgical site (e.g., clipping, use of antiseptic scrub/solution, etc.).*

Description: Since post capture holding time is minimal, no food or water is offered. Intramuscular injections of fentanyl and midazolam are administered separately with different syringes at dose rates adjusted to the purpose of handling. Darting is not used because otters are usually in the water and the risks of drowning or 'struck and loss' are too great. We use target dose rates of 0.33 mg/kg of fentanyl and 0.11 mg/kg of midazolam for surgical procedures, and 0.22 mg/kg fentanyl and 0.07 mg/kg of midazolam for non-surgical, biological sampling procedures as recommended by Monson et al. (2001). If anesthesia is not complete after approximately 15 minutes, additional fentanyl may be given. If 2-times the initial fentanyl dose is incrementally reached, and sedation is still not complete, the antagonist is given and the animal released without further handling (this is rarely observed). In the event of excessive tremors or convulsions, additional intravenous midazolam may be administered. Inhalant agents, such as isoflurane or sevoflurane, may be used as needed should anesthetic depth be deemed inadequate by the attending veterinarian. Also, based on the best judgment of the attending veterinarian, local anesthetics such as bupivacaine may be applied when potentially painful procedures are considered in the case of animals that are immobilized with lower doses or when anesthetic depth be deemed inadequate. Consistent with sound veterinary surgical practice, abdominal surgery, including implantation of VHF and/or TDR's is done with aseptic technique. Modifications of traditional methods are necessary, however, in order to accommodate the need for immediate post-operative return to the wild and preservation of the integrity of the sea otter's pelage due to its importance in thermoregulation. Rather than shaving the fur from the surgical site, the fur overlying the ventral midline is parted with a fine-toothed comb and held in place with a combination of water soluble, sterile surgical lubricating jelly and aqueous 10% solution of povidoneiodine.

d) Describe the facility or the area where the surgery will be performed:

Include

- *how it is prepared before each surgery;*
- *how surgical instruments are prepared; and*
- *how individuals responsible for surgery prepare themselves.*

Description: For captures in the vicinity of Monterey, surgeries and animal processing will be done in the state-of-the-art Animal Health Lab at the Monterey Bay Aquarium. For captures in more remote locales, surgeries may be conducted in an advanced mobile vet lab (provided by the California Department of Fish & Wildlife) or on a large research vessel in even more remote areas. In conformity with established veterinary surgery protocols, surgical surfaces and surroundings will be disinfected and instruments autoclaved or cold disinfected prior to surgery. Veterinary surgeons will scrub, and wear proper surgical attire and nitrile gloves.

SURGICAL PROCEDURES

a) Provide a brief description and/or citation of methods for all surgical procedures to be performed.

Include

- *incision site;*
- *procedures to be performed;*
- *anticipated duration of procedure; and*
- *method of wound closure including type and size of suture/staples.*

Description: VHF transmitters and TDRs are internally implanted, rather than being externally attached as in many marine mammal species, because 1) sea otters are unable to tolerate external attachments that might compromise their pelage (which is critical for thermoregulation), and 2) attached instruments similar to those used on pinnipeds would compromise their swimming and foraging abilities because of their small size. Furthermore, because of the nature of sea otter grooming activity, they are capable of reaching and removing (or destroying) most existing types of externally-attached tags. Consistent with sound veterinary surgical practice, abdominal surgery, including implantation of VHF and/or TDR's is done with aseptic technique. Modifications of traditional methods are necessary, however, in order to accommodate the need for immediate post-operative return to the wild and preservation of the integrity of the sea otter's pelage due to its importance in thermoregulation. Rather than shaving the fur from the surgical site, the fur overlying the ventral midline is parted with a fine-toothed comb and held in place with a combination of water soluble, sterile surgical lubricating jelly and aqueous 10% solution of povidone iodine. Access into the abdominal cavity is through an appropriately sized (6-10 cm) incision through the linea alba. Individually sterilized VHF transmitters and/or TDR's are then placed directly into the abdominal cavity, or in the case of TDR's may be inserted into the adipose tissue stored in the falciform ligament. If deemed necessary by the surgeon a solution of diluted antibiotic may be infused into the body cavity prior to closure. During the course of abdominal surgeries, the veterinarian may obtain small samples (5 g or less) of liver and/or adipose tissue, using appropriate biopsy techniques. The liver may be biopsied via a laparotomy and the traditionally described guillotine method in which a ligature is placed around an appropriate liver margin, tightened, and the entrapped portion of liver excised. Minimally invasive surgical methods utilizing rigid endoscopic technology are also appropriate for smaller samples. In this technique, the peritoneal cavity is insufflated with gas, a rigid endoscopic telescope and clam-shell biopsy forceps are inserted through two aseptically placed trocar/cannulas. Under direct visualization, multiple, up to six, biopsies of the liver can be collected. Samples of adipose tissue (fat) may be collected during routine surgical procedures as needed. These samples of up to 5 gm weight may be harvested from either the subcutis or from the falciform ligament, which typically contains large quantities of fat. Since sharp dissection and excision of fat samples is typically utilized, appropriate attention to hemostasis will be employed. Liver samples are used for analysis of contaminant exposure, while fat samples can be used for fatty acid analysis, an analytical procedure that (in conjunction with stable isotope analysis of vibrissae samples) can be used to quantify individual diets. A multi-layer, typically consisting of 4 separate suture lines, linea alba, subcutaneous fat/muscle, subcuticular, and skin, closure is meticulously performed to assure a water-tight seal, as well as to mitigate the potential for dehiscence either due to technique or self-mutilation. A sterile, mono-filament suture which is minimally reactive, provides adequate longevity, yet is absorbed over time is used to close surgical incisions. In addition to the process described above, additional safeguards are applied during instrument extraction/replacement surgeries. Since surgeries of this nature are more invasive with larger incisions, and greater duration, additional prophylactic measures are taken. In addition to the surgical drapes attached to the skin a secondary sterile draping system is utilized being affixed to either the subcutis or through a specialized sterile wound retractor. A broad spectrum, extended duration antibiotic is administered in conjunction with surgery. Any significant pathology encountered intra-operatively will be investigated within the limits of the patient's well being. A record of the surgical procedure and associated findings is completed following each procedure.

b) Describe procedure(s) employed to ensure aseptic technique is maintained throughout surgical procedure.

Include

- *sterilization method used for instruments, equipment and supplies;*
- *sterilization methods such as the use of sterile gloves, gowns, drapes, mask, cap, sterile implants, and sterile suture/closure material; and*
- *if same surgical instruments are used for multiple animals, describe how the instruments are managed to assure continued sterility.*

Description: Aseptic surgery performed on sea otters will be performed in an appropriate dedicated surgery area. In these cases, only appropriate facilities as determined by the attending veterinarian shall be utilized. Surgical procedures are to be performed by or under the direct supervision of licensed veterinarians with experience in sea otter medicine and surgery. Veterinary training will take a secondary role to the well-being of the sea otter patient. Appropriate care in the aseptic preparation of surgical sites, instruments, and surgeon consistent with accepted "standards of care" for practicing veterinary clinics is to be applied. An exception to this standard is the need to maintain thermal regulatory abilities within the sea otter. As a result, in most cases fur is not to be shaved from surgical sites. Instead, a mix of povidone-iodine solution and sterile water-soluble lubricating gel is used to create a "part" in the pelage. This part should extend down to skin level and be longer than the intended surgical incision. Adequate gel is to be applied to assure holding the fur back from the incision. In certain cases, it may be appropriate to secure secondary drapes to the subcutis intra-operatively to isolate the surgical area from the potential contamination associated with the pelage.
Sterilization method used for instruments, equipment and supplies: Three methods of sterilization will be employed. Durable instruments, such as surgical instruments will be steam sterilized in a standard autoclave. Efficacy will be monitored by indicator strips and the autoclave routinely evaluated using a biological indicator test system to confirm sterilization. Electronic instruments, such as radios and data collectors like TDRs, will be sterilized using a low temperature hydrogen peroxide plasma sterilization system. Delicate instruments which may be used multiple times but are not tolerant of autoclave temperatures and pressures, will be sterilized utilizing cold chemical sterilization with glutaraldehyde in accordance with manufacturer instructions. Single use, disposable items, such as scalpel blades, suture material, and surgical drapes will be purchased pre-sterilized and discards after use on a single patient. Sterilization methods such as the use of sterile gloves, gowns, drapes, mask, cap, sterile implants, and sterile suture/closure material: As described above, traditional aseptic technique will be employed whenever possible. Sterile instruments, gowns, and gloves will be utilized. The surgical theatre will be designed and managed in such a fashion as to minimize potential contamination of surgical sites and equipment. If same surgical instruments are used for multiple animals, describe how the instruments are managed to assure continued sterility: Instruments and equipment will be cleaned with soap and water and then sterilized in accordance with guidelines provided above. Items typically considered to be single use, such as scalpel blades, suture material, surgical gloves, and paper surgical gowns will be discarded after use on a single patient. Some more durable items, such as surgical towels, which are considered single use items in human medicine may be cleaned (laundered) and sterilized between patients. If cleaning and sterilization is not possible, they will be discarded between patients.

c) Identify all individuals performing surgery and describe their training and experience with regard to surgery involving the study species.

Name and Title	Surgery Performing	Experience

Michael J. Murray DVM, Jane Dunaway Director of Veterinary Services, Monterey Bay Aquarium	Primary veterinarian performing surgery and overseeing the medical aspects of sea otter handling.	Dr. Murray has been the primary veterinarian for most of the field work done on sea otters for the past 20 years and has worked in the field throughout the sea otter range from Russia to California. In his role at the Monterey Bay Aquarium, he has trained at least 10 veterinarians from other agencies and institutions on sea otter medicine and surgery. Other veterinarians will participate in sea otter work, however, their involvement will be directly overseen by Dr. Murray to minimize risk to the otter and maximize efficiency of the veterinary lab.
Dave Casper, DVM, Attending Veterinarian at UC Santa Cruz		Clinical veterinarian for 45 years with extensive experience in small mammal, avian, and marine mammal medicine. Management experience includes owning and operating own animal hospital and being head of department at the John G. Shedd Aquarium in charge of laboratory, veterinary services, and coordinating research. Research experience includes involvement with Long Marine Laboratory for the last 35 years assisting researchers with health care problems and field research, assisting with field research on bottlenose dolphins in Sarasota Florida, and Port O'Connor, Texas, and Beaufort, North Carolina, as well as coordinating the research program at the Shedd Aquarium. Holds position as UCSC attending veterinarian office at Long Marine Lab. A member of the UCSC Institutional Animal Use and Care Committee and the veterinarian/director for the UCSC marine mammal stranding network, and Director of the UCSC Vivarium. Have position as

		backup veterinarian at MBA for the last 10 years. Have worked on Sea otter captures for the last 12 years.
Claire Simeone, DVM, The Marine Mammal Center		Dr. Claire Simeone has seven years' experience working with marine mammals, including sea otters. She has provided medical care for sea otters both in a rehabilitation and captive setting, and has sedated roughly a dozen southern sea otters. She has performed both implant and explant surgeries under the observation of Dr. Mike Murray.
Shawn Johnson, DVM, Director of Veterinary Science at The Marine Mammal Center		Dr. Shawn Johnson is Director of Veterinary Science at The Marine Mammal Center and oversees all of the Rescue, Animal Care, Diagnostic Services, and Research activities. Dr. Johnson has more the 20 years of marine mammal veterinary medicine experience and has cared for sea otters in rehabilitations at the Alaska SeaLife Center and The Marine Mammal Center and participated in two sea otter captures trips performing anesthesia, sampling, and implant surgeries under the guidance of Dr. Mike Murray.
Cara Field, DVM, Staff Veterinarian at The Marine Mammal Center		Dr. Cara Field is the Staff Veterinarian at The Marine Mammal Center (TMMC) in Sausalito California, since October, 2014. Her primary roles include managing the care and rehabilitation of our marine mammal patients including sea otters, as well as carrying out research projects and teaching our veterinary intern and visiting veterinary residents, international vets and students among others. Sea otter specific experience includes primary medical care of

		2 captive sea otters at Audubon Nature Institute for 2.5 years, medical care of 5 captive sea otters at Georgia Aquarium for 2.5 years, primary responsibility for the rehabilitation of sea otters at TMMC, collaboration with the Monterey Bay Aquarium sea otter rehabilitation program, participation in sea otter transmitter implant surgeries, and collaborator with the US Fish and Wildlife and OWCN response groups.
Lesanna Lahner, DVM, Associate Veterinarian, Minnesota Zoo		Dr. Lahner has worked with sea otters since 2011. Over the past 7 years, Dr. Lahner has been fortunate to be mentored by Dr. Michael Murray on the topics of sea otter field surgery, medicine of captive sea otters, and husbandry related practices. During that time, Dr. Lahner has performed a variety of medical and surgical procedures on sea otters from the treatment gastrointestinal disorders to lensectomies. Dr. Lahner was honored to co-author the Sea Otter Medicine chapter in the most recent CRC Marine Mammal Medicine text.
Heather Harris, DVM, The Marine Mammal Center		Dr. Harris is a wildlife veterinarian and a board-certified specialist in veterinary preventive medicine. She completed a dual degree program at the University of California, Davis with a doctorate in veterinary medicine and a masters in wildlife epidemiology, followed by a clinical internship in marine mammal medicine and pathology at The Marine Mammal Center. Dr. Harris is on the faculty at Cal Poly San Luis Obispo in the Animal Science Department and serves as the contract veterinarian for The Marine Mammal Center at

		the San Luis Obispo Field Office, where she regularly provides emergency and critical care to sick and injured sea otters. Dr. Harris has almost 20 years of sea otter research and clinical experience under various collaborative roles associated with the Southern Sea Otter Research Alliance. She has performed all aspects of veterinary care during sea otter field captures including physical restraint, anesthesia, biological sampling, tagging, and surgical implant and explant procedures.
Raymond Wack, DVM, Senior veterinarian at the Wildlife Health Center, Veterinary Director at the Sacramento Zoo		As a senior veterinarian at the Wildlife Health Center, Dr. Wack serves as Veterinary Director at the Sacramento Zoo as well as Service Chief for Zoological Medicine at the UCDavis Veterinary Medical Teaching Hospital. Dr. Wack has 30 years of experience in clinical practice of zoological medicine including the care of sea otters and river otters of several species. Dr. Wack has previously worked with Dr. Mike Murray on sea otter transmitter implantation surgeries as well as participated in Dr. Murray's training workshops. Specific sea otter experience includes restraint, sedation, physical examination, blood draw, sample & morphometric data collection, and surgical transmitter placement surgeries. Dr. Wack is responsible for the Zoological Medicine Residency Program which is a collaboration with UCDavis SVM, Sacramento Zoo, San Diego Zoo Global and SeaWorld San Diego. Dr. Wack provides didactic and clinical training to veterinary students interested in zoological medicine. His current research interests are

		wide ranging from discovering a new amdoparvovirus in red pandas to implanting radio transmitters in giant garter snakes.
Nancy Anderson, DVM, Oiled Wildlife Network		Coordinates wildlife field care and processing activities for the Wildlife Health Center's Oiled Wildlife Care Network (OWCN). As a key manager for the OWCN's oil spill response team, lead wildlife field stabilization and evidence collection operations during oil spill response for birds, marine mammals, sea otters, sea turtles and all inland wildlife species. Collaborate with other wildlife veterinarians, biologists and wildlife rehabilitators to develop field husbandry and medical care protocols for oiled wildlife. During non-spill periods, ensure oil spill readiness by developing curriculum and leading training workshops for staff and volunteers from Member Organizations and Affiliated Agencies throughout California. Engage in research activities to ensure 'best achievable collection and care of oiled wildlife. Current research projects are focused on improving warming therapies for hypothermic seabirds and evaluating blood chemistries of debilitated seabirds at initial presentation to develop a sound scientific basis for rehydration therapy protocols. Hire and oversee field staff and volunteers. Supervise the acquisition and management of supplies and equipment necessary for field stabilization and processing operations, including mobile animal care facilities. Active in university teaching and public service activities. Since 2012, I have worked with USGS

		biologists/researchers and Dr. Mike Murray on research projects involving sea otters. Specific sea otter experience includes restraint, sedation, physical examination, blood draw, sample & morphometric data collection, and surgical transmitter placement surgeries. I was the primary author for the Field Stabilization section of "OWCN Protocols for the Care of Oil-Affected Sea Otters" and have been the Field Stabilization Group Supervisor for annual drills held at MVWCRC to train personnel and test readiness to respond in the event of a petroleum spill that affects sea otters.

Anesthesia

a) Provide a brief description of anesthetic procedures.

Describe

- *agent;*
- *dose (i.e., mg/kg or % if by inhalation);*
- *route of administration;*
- *expected duration of anesthesia;*
- *monitoring procedure to evaluate depth of anesthesia;*
- *maintenance and monitoring procedures to ensure normal body temperature is maintained in the animal;*
- *procedures to be employed in case of anesthetic emergency such as over-dose; and*
- *monitoring protocol to ensure animal's complete recovery from anesthesia; if by inhalation describe the equipment used and state the method of scavenging waste anesthetic gas/fumes; if injectable agent(s) are not commercially prepared and sterility guaranteed, please describe method used to assure the agent's sterility when injected;*
- *safety mechanisms to prevent personnel exposure to volatile anesthetics.*

Description: Intramuscular injections of fentanyl and midazolam are administered separately with different syringes at dose rates adjusted to the purpose of handling. Darting is not used because otters are usually in the water and the risks of drowning or 'struck and loss' are too great. We use target dose rates of 0.33 mg/kg of fentanyl and 0.11 mg/kg of midazolam for surgical procedures, and 0.22 mg/kg fentanyl and 0.07 mg/kg of midazolam for non-surgical, biological sampling procedures as recommended by Monson et al. (2001). If anesthesia is not complete after approximately 15 minutes, additional fentanyl may be given. If 2-times the initial fentanyl dose is incrementally reached, and sedation is still not complete, the antagonist is given and the animal released without further handling (this is rarely observed). In the event of excessive tremors or convulsions, additional intravenous midazolam may be administered. Inhalant agents, such as isoflurane or sevoflurane, may be used as needed should anesthetic depth be deemed inadequate by the attending veterinarian. Also, based on the best judgment of the attending veterinarian, local anesthetics such as bupivacaine may be applied when potentially painful procedures are considered in the case of animals that are immobilized with lower does or when anesthetic depth be deemed inadequate. The reversal agent Naltrexone is administered intramuscularly, at a dose equal to 2-5 times the fentanyl dose, immediately following handling. Naltrexone has a rapid onset and the initial "first response" time is typically noted within one minute. Monitoring by an experienced team member continues until reversal is complete and the animal is deemed releasable by the attending veterinarian. Body temperature is monitored by a team member throughout the procedure. In addition, sterile oxytocin (20 units/ml) may be injected intramuscularly to facilitate milk letdown in lactating females. Oxytocin, a hormone produced by the hypothalamus stimulates contraction of the smooth muscle of the mammary glands to release milk. We will only attempt to collect milk samples from females with dependent pups, no pregnant females or females without pups will be given oxytocin.

b) Identify the individual(s) performing and monitoring anesthesia. Describe that person's training and experience with regard to the administration of anesthesia for the study species.

Name and Title	Procedure Performed	Experience
Marissa Young RVT	Primary veterinary technician managing sea otter anesthetic monitoring and maintenance.	California-licensed veterinary technician and has been the primary veterinary tech for most of the field work performed in California for approximately 15 years. She is the veterinary technician at the Monterey Bay Aquarium and has experience in sea otter nursing care, including anesthesia, surgical assisting, clinical pathology, and diagnostic imaging. She has also been the primary instructor for a number of veterinary technicians and assistants from other institutions and agencies. Other technicians will participate in sea otter work, however, their involvement will be directly over seen by Ms. Young to minimize risk and maximize efficiency of the veterinary lab.

POST-OPERATIVE PROCEDURES AND CARE

a) Provide a brief description of all post-operative procedures and care.

Include

- *criteria to assess animal pain and the need for analgesics;*
- *type of post-operative analgesics (describe agent, dose, route of administration, frequency, duration of treatment);*
- *techniques used to ensure maintenance of normal body temperature in the animal;*
- *incision care, monitoring and time of suture removal;*
- *catheter or long term care of any chronically instrumented/implanted animals, monitoring and time of removal; and*
- *bandage/dressing monitoring and changing schedule.*

Description: After the reversal drug is administered, the attending DVM will determine that the otter is alert, responsive, and ready for release. The temperature sensitive PIT tag allows for a final temperature reading to be collected after the otter is alert, in order to ensure that body temperature is within the normal range. The otters are then released back to the original capture site as soon as possible post surgery(once fully alert), as past experience has shown that otherwise healthy otters recover much better in the natural environment than in a captive situation. The animals are monitored closely during the release process, and immediately thereafter by shore-based observers with telescopes. to ensure a quick return to normal activity. Subsequently, attempts are made to locate each otter on a daily basis for the next 2-3 years (in rare situations we may only be able to locate specific otters 2-3 times a week if otters move to a location where shore-based access is limited), with observers paying particularly close attention to the animals health and behavior for the first 4 weeks after the surgery. Any animals that appear to be in acute distress during the first 4 weeks post-release may be re-captured for examination and treatment by a veterinarian, with such decisions made on a case-by-case basis at the discretion of the PI in consultation with a veterinarian and the US Fish and Wildlife Service. Note that the close collaboration of the PI with the Monterey Bay Aquarium (MBA) and The Marine Mammal Center (TMMC) means that there is an ability to respond to an animal in distress 7 days a week, 365 days a year.

b) If post-operative analgesics will not be used, provide scientific justification.

Description: If animals are released immediately after handling, there is no opportunity to provide post-operative analgesics. In the rare case in which significant pain is anticipated post-procedure, such as an unexpected orthopedic procedure, efforts are made to work with a permit-bearing facility with the capacity to care for sea otters. The animal will be held and managed with analgesics until such time as it is deemed to be suitable for release. More specifically, if the attending veterinarian feels that the circumstances associated with the surgical procedure were such that significant post-operative analgesics are indicated, the otter will be transferred to the nearest marine mammal rehabilitation or holding facility with sea otter holding capabilities, such as Monterey Bay Aquarium, California Department of Fish & Wildlife Marine Wildlife Veterinary Care & Research Center, The Marine Mammal Center, Aquarium of the Pacific, or Sea World San Diego. Transport, holding, and care protocols will be in accordance with the facility's standard operating procedures.

c) Describe arrangements for post-operative monitoring of animals, the individual(s) responsible for performance of monitoring, including after-hour, weekend and holiday care (if applicable).

Name and Title	Procedure Performed	Experience

Description: As described above, animals are not held for any period of time after reversal of anesthesia.

d) Describe the use of any antibiotics or other therapeutic drugs.

Include

- *agent;*
- *dose (i.e. mg/kg, IU/kg);*
- *route of administration; and*
- *frequency, duration of treatment.*

Description: Emergency drugs, when administered, are given at traditional terrestrial carnivore doses. The routine administration of drugs is limited to post-procedure antibiotics. For invasive surgery the drug, cefovecin, is administered at a dose of 8 mg/kg SQ. Pharmacokinetic studies in the sea otter indicate that therapeutic blood levels are maintained for approximately 5 days. In the cases in which non-invasive procedures, such as blood sampling or flipper tagging, are performed, a combination of procaine and benzathine penicillin are administered at doses of 50,000 U/kg IM. While not validated, it is believed that blood levels persist for 48 hrs in the sea otter.

e) If this surgical procedure induces a disease or other functional alteration, describe any anticipated adverse effects and deficiencies, monitoring protocol/schedule for animals, animals' degree of tolerance to disease/functional deficit.

Description: NA

MULTIPLE SURGERIES

Will animals be subjected to more than one (1) survival surgery? Yes ☒ No ☐

If yes, provide scientific justification and explain how surgeries are related.

Description: Time depth recorders must be retrieved in order to download recorded data. Attempts to develop externally attached TDRs for sea otters have not been successful (to-date). Based on our past experience in Alaska and California, multiple surgeries have not resulted in additional complications or significant increased risks for study animals.

SECTION IX: LITERATURE CITED

PLEASE PROVIDE COMPLETE CITATIONS OF ALL LITERATURE CITED TO SUPPORT THIS PROTOCOL.

Click or tap here to enter text.

Arnemo, JM, P Dypsund, et al. (1997). “Surgical implantation of radio transmitters in wolverines.” Norsk Veterinaertidsskrift **109(2): 103-104.**

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Guidelines for Zoo and Aquarium Veterinary Medical Programs and Veterinary Facilities. American Association of Zoo Veterinarians, 1999.

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Williams, TM and L Yeates (2005). "The energetics of foraging in large mammals: a comparison of marine and terrestrial predators." International Congress Series **1275: 351-358.**

SECTION X: DECLARATION (ONLY COMPLETE ONE)

A) THE INFORMATION PROVIDED HEREIN IS AN ACCURATE DESCRIPTION OF MY ANIMAL CARE AND USE PROTOCOL(S). ALL PEOPLE STUDYING ANIMALS UNDER THIS PROTOCOL HAVE BEEN OR WILL BE PROPERLY TRAINED TO USE APPROPRIATE METHODS AND HAVE READ AND AGREED TO COMPLY WITH THIS PROTOCOL. ALL INDIVIDUALS WORKING UNDER THIS ASSURANCE WILL COMPLY WITH THE PROCEDURES AND METHODS OUTLINED IN THE INTERAGENCY RESEARCH ANIMAL COMMITTEE'S *U.S. GOVERNMENT PRINCIPLES FOR THE UTILIZATION AND CARE OF VERTEBRATE ANIMALS USED IN TESTING, RESEARCH, AND TRAINING*, THE ANIMAL WELFARE ACT AND ITS IMPLEMENTING REGULATIONS, AND THE PUBLIC HEALTH SERVICE POLICY EXCEPT AS OTHERWISE AUTHORIZED BY THE APPROVAL OF THIS PROTOCOL.

ALL WORK PROPOSED HEREIN IS DESIGNED TO AVOID DISCOMFORT, DISTRESS, AND PAIN TO ANIMALS TO THE EXTENT POSSIBLE; DOES NOT UNNECESSARILY DUPLICATE PREVIOUS EXPERIMENTATION; AND NON-ANIMAL ALTERNATIVES HAVE BEEN CONSIDERED.

1/30/2019

X Julie Yee

Julie Yee
Principal Investigator
Signed by: Geological Survey

B) THE INFORMATION PROVIDED HEREIN IS ACCURATE AND TRUE ACCORDING TO THE DEFINITIONS PROVIDED. I CERTIFY THAT THIS PROJECT DOES NOT ENTAIL THE STUDY OF LIVE VERTEBRATES AS DEFINED.

PRINCIPAL INVESTIGATOR

DATE

C) THE INFORMATION PROVIDED HEREIN IS ACCURATE AND TRUE ACCORDING TO THE DEFINITIONS PROVIDED. I CERTIFY THAT THIS PROJECT MEETS THE DEFINITION OF A FIELD STUDY AND DOES NOT INCLUDE PROCEDURES SUCH AS SURGERY, IMPLANTING TELEMETRY DEVICES OR ANY OTHER INVASIVE PROCEDURES, AND DOES NOT MATERIALLY ALTER THE BEHAVIOR OF THE ANIMAL/SPECIES UNDER STUDY. SHOULD ANY OF OUR METHODS SIGNIFICANTLY CHANGE, MEANING THE DEFINITIONS/REQUIREMENTS OF A FIELD STUDY AS DEFINED ABOVE ARE NO LONGER MET, I WILL SUPPLY THE ADDITIONAL INFORMATION REQUESTED IN THIS FORM AND NOTIFY ACUC PRIOR TO IMPLEMENTING THE CHANGE.

PRINCIPLE INVESTIGATOR

____

DATE

____

APHIS Category B: Animals being held for use in teaching, procedures, or research, but not yet used for those purposes.

Examples:

- *Mere holding of animals captive for observational purposes*

APHIS Category C: Procedures that produce no pain or distress, no use of pain-relieving drugs.

Capture is an essential element of most wildlife studies. For the purpose of determining the appropriate categorization of capture, the American Society of Mammalogists and the Ornithological Council analyzed existing guidance used by APHIS and the NIH Office of Animal Care to determine that most methods of capture in properly functioning devices with appropriate monitoring by field staff would constitute Category C. Free-ranging mammals captured in live traps and subsequently euthanized as part of the research study or that are taken in properly functioning kill-traps meet the standards for either USDA category C or D; the distinction between these reporting categories depends upon how the animal dies. Animals taken in live traps that show no obvious signs of pain or distress and subsequently euthanized using accepted methods that avoid inducing pain or distress and those taken in properly functioning kill traps fit the definition for reporting under USDA category C. This conclusion is consistent with example #4 in the USDA APHIS Research Facility Inspection Guide (section 14.1.10) except that death is intentional rather than unexpected. The Research Facility Inspection Guide pertains to laboratory animals rather than free-ranging wildlife, but euthanasia following a live capture that does not result in pain or distress is analogous to this example.

Mammal capture devices are designed either to hold the animal unharmed (live-traps) or to kill the animal outright upon capture. The guidelines of the American Society of Mammalogists for the use of wild mammals in research discuss appropriate methods and trap types for capturing or collecting free-ranging mammals (Gannon et al. 2007).

Barring mechanical malfunctions and with appropriate placement and trap-checking frequency, animals captured in live-traps or nets are simply held without injury until removal. Appropriate training is essential for setting capture devices and for removing animals from those devices. Pain or distress, as described in the APHIS Animal Care Resource Guide, is unlikely to result from the simple capture of free-ranging mammals using most live traps or capture techniques covered in the American Society Mammalogists, so animal usage in these instances is consistent with USDA category C.

Other example of Category C procedures in wildlife research:

- *Individual or small numbers of animals being confined and maintained in natural habitat that affords an appropriate quantity and quality of food, cover, and water*
- *The short-term and skillful restraint of animals for purposes of observation or physical examination*
- *Injection of material in amounts that will not cause adverse reactions by the following routes: intravenous, subcutaneous, intramuscular, intraperitoneal, or oral, but not intrathoracic or intracardiac*
- *Acute non-survival studies in which the animals are completely anesthetized and do not regain consciousness*
- *Approved methods of euthanasia or humane killing*
- *Short periods of food and/or water deprivation equivalent to periods of abstinence in nature.*
- *Collection of feathers, small skin punches, urine, feces, tracheal swabs, cloacal swabs*
- *Application of tagging or marking devices, except implantations into body cavities*

- *Most blood collection procedures.*
- *Administration of an anesthetic, analgesic or tranquilizing drug to an animal for restraint purposes to perform a procedure that involves no pain or distress.*

Most tissue sampling and marking techniques in the field also are consistent with USDA pain category C provided that procedures are not more invasive than peripheral blood sampling. Support for this classification is provided in the Guidelines for Preparing USDA Annual Reports and Assigning USDA Pain and Distress Categories. This document is distributed by the NIH Office of Animal Care and Use, which is the oversight office for intramural research. This guidance expressly states that Category C includes most blood and tissue collection procedures that involve no or only momentary or slight pain.

APHIS Category D: Procedures involving pain or distress for which appropriate anesthetic, analgesic, or tranquilizing drugs were used.

Examples:

- *Surgical implantation of telemetry devices or identification devices that require anesthesia or analgesia*
- *Invasive tissue sampling, such as intracardial blood draws or invasive biopsies*

APHIS Category E: Procedures that involve pain or distress for which the use of anesthetics, analgesics, or tranquilizers would have adversely affected the procedure, results, or interpretation of the results.

Examples:

- *Experimental increase of litter or clutch size that results in a statistically significant depression in growth rates, excessive loss of parental mass, or death of young or adults.*
- *Diets that cause a statistically significant reduction in growth or cause excessive loss of body mass.*

DEPARTMENT OF THE INTERIOR
U.S. FISH AND WILDLIFE SERVICE

FEDERAL FISH AND WILDLIFE PERMIT

1. PERMITTEE

U.S. GEOLOGICAL SURVEY
100 SHAFFER ROAD
CENTER FOR OCEAN HEALTH
RM 251
SANTA CRUZ, CA 95060
U.S.A.

2. AUTHORITY-STATUTES
16 USC 1533 (d)
16 USC 1371 (a) (1)

REGULATIONS
50 CFR 17.32
50 CFR 18.31

3. NUMBER
MA672624-18 AMENDMENT

4. RENEWABLE
☒ YES
☐ NO

5. MAY COPY
☒ YES
☐ NO

6. EFFECTIVE
09/13/2013

7. EXPIRES
09/12/2018

8. NAME AND TITLE OF PRINCIPAL OFFICER *(If #1 is a business)*
M. TIM TINKER
RESEARCH WILDLIFE BIOLOGIST

9. TYPE OF PERMIT
THREATENED MARINE MAMMAL SCIENTIFIC RESEARCH

10. LOCATION WHERE AUTHORIZED ACTIVITY MAY BE CONDUCTED
RANGE OF SOUTHERN SEA OTTERS IN CALIFORNIA WATERS

11. CONDITIONS AND AUTHORIZATIONS:

A. GENERAL CONDITIONS SET OUT IN SUBPART D OF 50 CFR 13, AND SPECIFIC CONDITIONS CONTAINED IN FEDERAL REGULATIONS CITED IN BLOCK #2 ABOVE, ARE HEREBY MADE A PART OF THIS PERMIT. ALL ACTIVITIES AUTHORIZED HEREIN MUST BE CARRIED OUT IN ACCORD WITH AND FOR THE PURPOSES DESCRIBED IN THE APPLICATION SUBMITTED. CONTINUED VALIDITY, OR RENEWAL, OF THIS PERMIT IS SUBJECT TO COMPLETE AND TIMELY COMPLIANCE WITH ALL APPLICABLE CONDITIONS, INCLUDING THE FILING OF ALL REQUIRED INFORMATION AND REPORTS.

B. THE VALIDITY OF THIS PERMIT IS ALSO CONDITIONED UPON STRICT OBSERVANCE OF ALL APPLICABLE FOREIGN, STATE, LOCAL, TRIBAL, OR OTHER FEDERAL LAW.

C. VALID FOR USE BY PERMITTEE NAMED ABOVE.

D. Acceptance of this permit serves as evidence that the Permittee understands and agrees to abide by the "General Permit Conditions" (copy attached).

E. The permittee is authorized to take and transport up to a total of 726 southern sea otters (Enhydra lutris nereis) in California waters for the purpose of scientific research as described in the tables in Condition J), in Permittee's application file and conditioned below.

F. Authorized to take and release southern sea otters of all ages and sexes as described in application including the following: Capture/, transport, immobilize, drug, hold, measure and release; flipper tag (including using "smart tags"); inject with radio-frequency identification tags; collect biological samples (see Condition J, Table 2); and surgically implant VHF transmitter/ TDR packages (and remove from same) by a veterinarian authorized under this permit.

G. Authorized to collect salvaged specimens and carcasses and samples from the carcasses, as described in Condition J, from unlimited carcasses and salvaged remains each year.

CONDITIONS CONTINUE ON NEXT PAGES.

☒ ADDITIONAL CONDITIONS AND AUTHORIZATIONS ALSO APPLY

12. REPORTING REQUIREMENTS
SUBMIT COMPLETE REPORT AS REQUIRED BY COND. R TO DMA AND VFWO, BY 1/31 FOLLOWING EACH YEAR PERMIT IS IN EFFECT.

ISSUED BY

TITLE FOR
CHIEF, BRANCH OF PERMITS, DMA

DATE
09/13/2013

MA672624-18
USGS Center for Ocean Health

H. Authorized for Level B harassment[1] of up to 1,290 sea otters annually.

I. Not authorized to incidentally harass other marine mammal species. Every effort should be made to ensure that other marine mammal species than southern sea otter are not in the immediate area prior to commencing authorized activity as described in Permittee's application and supplemental file information. Should any other marine mammal species be encountered during authorized activities, Permittee must immediately move away from the site and detour around the animals.

J. **Take Tables:**

Table 1. Total Authorized Takes of Live Southern Sea Otters (*Enhydra lutris nereis*)

	Total Take	**Anesthesia/Tag/Tissue Sample**	**Surgically Implant**	**TDR Implant**	**Recapature 3x Annually**
Previously Permitted	850	600	325	173	100
Used	634	594	305	153	2
Remaining	216	6	20	20	98
	Total Take	**Anesthesia/Tag/Tissue Sample**	**Surgery Implant/Explant**	**Incidental To Captures**	
New Requested	500	400	200	100	
Permit Total	726	406	220	100	

[1] any act of pursuit, torment, or annoyance which has the potential to disturb a marine mammal or marine mammal stock in the wild by causing disruption of behavioral patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering.

Table 2. Samples Authorized for Collection from Captured Sea Otters or Beach-cast Remains.

Sample Type	Live/Carcass	Amount Collected	Use	Comments
Blood	Live	5% blood volume (blood volume = 8% BW	Hematology, clinical chemistry, infectious disease monitoring, biomarkers, contaminants	Blood volume "lost" from animal to include collection, loss to hematoma, bleeding from tagging, and surgical bleeding
External swabs (integument, oral cavity, rectum, genital orifice	Live	No volume limitation	Infectious disease (bacterial, fungal, parasitic, viral), contaminants, genetics	
Saliva	Live	0.3 - 1.0 ml	Hormonal assays	
Feces	Live	No limit	Diet assessment, infectious disease (bacterial, fungal, parasitic, viral), contaminants, biotoxin, hormonal assay	From environment
	Live	< 100gm		Collected from rectum
Milk	Live	< 10 ml	Nutritional content, fatty acid analysis, contaminants	May require administration of oxytocin to cause release
Urine	Live	TBD by DVM	infectious disease, toxins, urinalysis, contaminants	Free catch or cystocentesis
Adipose tissue	Both	< 10 gm (live)	Fatty acids, contaminants	May require surgical intervention with appropriate consideration for anesthesia and surgical methodology.
		No limit (dead)		
External pathology (integument, oral cavity, genital orifice)	Both	TBD by DVM	Histopathology, genetics, etiopathogenetic investigation	May require surgical intervention with appropriate consideration for anesthesia and surgical methodology.
Liver biopsies	Both	< 2 gm (live)	Histopathology, toxicology, contaminants, genetics, chemical analysis (ie, Vit A analysis)	May require surgical intervention with appropriate consideration for anesthesia and surgical methodology.
		No limit (dead)		Collected at necropsy
Premolar tooth	Both	1	Cementum aging	First upper premolar, only
Skin plugs	Both	< 2 gm (live)	Genetics	Collected in association with flipper tagging in live animals
Vibrissae	Both	2	Stable isotope	
Baculum	Carcass	1	Morphometrics, stable/radio isotopes	
Tooth	Carcass	No limit (dead)	Cementum aging	
Skull	Carcass	1 or portions	Morphometrics, stable/radio isotopes	
Fur	Both	NMT 1 gm	Hormonal assays, toxins, contaminants	Collected by plucking as not to interfere with thermoregulation.

K. **Dr. Martin Tim Tinker is hereby designated as Principal Investigator (PI) under this permit; Jack Ames, Nancy Anderson (DVM), James Bodkin, Daniel Costa, George Esslinger, James Estes, Christine Fiorello (DVM), Heather Harris (DVM), Mike Harris, Brian Hatfield, David Jessup (DVM), Christine Kreuder-Johnson (DVM), Michael Kenner, Lesanna Lahner (DVM), Melissa Miller (DVM), Daniel Monson, Michael Murray (DVM), Seth Newsome, Michelle Staedler, Joseph Tomoleoni, Raymund Wack (DVM), Benjamin Weitzman, Terrie Williams, and Colleen Young are designated as Co-investigators.** Activities under this permit may only be conducted under the on-site supervision of the PIs or Co-investigators and, as applicable, any one of the Permittee's veterinarians (Dave Jessup and Michael Murray). The Permittee may designate any other personnel as Co-investigator(s), provided the individuals have received appropriate training and possess adequate proficiency to conduct the research activities in accordance with the permit conditions. Upon designation of additional Co-investigator(s), and any additional veterinarians, the Permittee must submit the individuals' CVs to the Division of Management Authority (DMA). The names of designated Co-investigator(s) and a list of other authorized personnel must be maintained in writing by the PIs for a period of not less than 5 years and provided to DMA upon request. **Permittee and all authorized personnel must have a copy of this permit and, if applicable, all other written approvals in possession while conducting all authorized activities.** Permittee must monitor each activity conducted under this permit to ensure that authorized takes are not exceeded and that authorized and highly skilled personnel perform permitted activities.

L. **<u>Capture/Re-Capture</u>**:

1) Three attending personnel and 2 shore-based spotters must be present during all capture activities, one of which should be Permittee personnel with extensive training and previous capture/rescue experience (see K. above for co-investigator requirements).
2) Prior to initiating any field captures/re-captures for the instrumentation procedures:
   (a) Each capture and spotting team must have on-hand an up-to-date list (i.e., updated since the most recent implantation surgery) of all animals previously captured;
   (b) This up-to-date list must include each otter's radio frequency and external tag identification;
   (c) Spotters must scan all radio-frequencies of otters likely to occur in the capture area that have been implanted within the past four weeks;
   (d) If a sea otter is positively identified as having undergone surgery within the past four weeks, it may not be targeted for re-capture (unless it is being purposefully targeted as required by Cond. M.6); AND
   (e) Once a captured otter has been brought alongside the capture vessel, the radio frequency and external tag must be checked and compared to the up-to-date animal list, and if it is determined that an otter has been mistakenly re-captured, it must be released immediately at the capture location.
3) Tangle nets may not be set if weather or sea state is, or is forecast to be, such that the recovery of entangled otters may be impeded. Nets must be monitored at least every 6 hours, or every 2 to 4 hours when visibility is poor.

4) Dip nets and underwater capture methods using a diver-held trap and net bag, as described in Permittee's application, may also be used.
5) Disturbance of animals should be minimized by exercising caution when approaching and capturing animals, particularly mother-pup pairs, and the approach must be halted if there is evidence that the activity may be interfering with pair bonding, nursing, reproduction, feeding or other vital functions.
6) To minimize the chance of mother-pup separation, mother and pup should be captured together and released simultaneously following the recovery period. Dependent pups must not be targeted, unless they are targeted along with their mothers. In the event that a pup is captured and not the mother, the pup must be immediately released and allowed to reunite without sampling.
7) Every feasible effort must be made to recover and treat animals showing signs of stress, aberrant behavior, or are orphaned as a result of the permitted activities. The animals must be fully recovered prior to release to ensure that there is no post-operative bleeding. A qualified veterinarian must be consulted any time animals being held are observed shivering or otherwise appear stressed and action shall be taken based on the veterinarian's advice.
8) Captured animals must be released in the proximity of the capture location.
9) In the event that a lactating female is killed or seriously injured as a result of the activities, the female's orphaned or abandoned pup must be humanely provided for (i.e. recovered and cared for or euthanized if absolutely necessary). Such events must be reported to DMA as described in condition O. below.

M. **Instrumenting Otters**:
1) Only qualified veterinarians are authorized to surgically implant radio transmitters and TDRs; pregnant females may be radio-or TDR-tagged at the discretion of the attending veterinarian.
2) Surgically implanted animals should be returned to the same location from which they were captured.
3) To minimize the chance of mother-pup separation following surgery, only sea otters captured with their pups can be surgically implanted so both the mother and pup can be released simultaneously following the recovery period.
4) Only sea otters weighing at least 20 pounds may be instrumented.
5) Monitoring of instrumented animals should be as extensive as possible. Attempts to locate individual animals should be made at least weekly, for approximately four weeks following surgery if possible, weather permitting.
6) Every feasible effort should be made to recover and treat instrumented otters that show signs of stress or aberrant behavior or are orphaned as a result of the permitted activities. The animals must be fully recovered prior to release to ensure that there is no post-operative bleeding. A qualified veterinarian must be consulted any time animals being held are observed shivering or otherwise appear stressed, and action shall be taken based on the veterinarian's advice.
7) The number of animals which are recaptured for subsequent surgical replacement of implanted radio transmitters is as described in Condition J and the permit application file.

7) The number of animals which are recaptured for subsequent surgical replacement of implanted radio transmitters is as described in Condition J and the permit application file. Replacement surgery may be performed no more than one time on any given animal without additional approval from the Division of Management Authority (DMA), in consultation with the Marine Mammal Commission.
8) Animals which are re-captured for subsequent surgical removal of implanted radio transmitters and/or TDRs should be closely monitored as in conditions M.5 and M.6, above.

N. **Photographs/Videotape/Film**: Researchers may obtain photographs, video, or film if such activities are essential to achieving the research objectives (e.g., documentation of research activities). However, researchers must obtain prior approval from DMA to use photographs, video, or film for non-research related purposes.

O. **In the event that ONE animal dies or is injured during or following permitted activities** and that mortality or injury can reasonably be attributed to such activities, the Permittee must immediately notify DMA (1-800-358-2104 or fax 703-358-2281 or by email) and the Fish and Wildlife Service's Ventura Fish and Wildlife Office (VFWO) (805-644-1766; fax: 805-644-3958) to describe the circumstances that led to the injury or mortality and to provide suggestions for measures to prevent or minimize the chances of future mortalities or injuries. DMA will have the discretion of changing permit conditions.

In the event that AN ADDITIONAL animal dies or is injured during or following permitted activities and the mortality and/or injury can reasonably be attributed to such activities:
1) Immediately suspend research activities until re-authorized by DMA;
2) Immediately notify DMA and VFWO and follow up such verbal notification with a written report detailing the circumstances that led to the injury or mortality and suggesting measures to prevent or minimize the chances of future mortalities or injuries;
3) DMA, in consultation with VFWO and the Marine Mammal Commission (MMC) may subsequently authorize continuation of the research with any necessary modifications/conditions or initiate revocation procedures.

P. Necropsies must be performed by a qualified veterinarian experienced in sea otter pathology on any animals that die during the project in order to evaluate both the long and short term effects of capture, handling, implants, etc. A copy of the necropsy report must be provided to DMA.

Q. Permittee (and authorized research collaborators) must maintain compliance with all provisions of a Registered Research Facility under the Animal Welfare Act as required by the U.S. Department of Agriculture, Animal and Plant Health Inspection Service. Upon expiration of Permittee's Institutional Animal Care and Use Committee (IACUC) approval, documentation of an extension of this approval must be provided to DMA.

R. **Annual Reporting Requirements:** In accordance with block 12 of this permit, copies of an Annual Report of the previous year's activities must be submitted by January 31 to DMA: 4401 North Fairfax Drive, Room 212, Arlington, Virginia 22203 and to VFWO, 2493 Portola Road, Suite B, Ventura, CA 93003. The Annual Report shall include at a minimum the following:

1) A summary of research activities conducted.
2) For captures, tabulation of sea otters (tabulate mother/pup pairs as in 3. below) captured indicating: age, sex, weight, type of mark (i.e. tags), tissue samples taken, dates of capture and release and date last observed (if observed since release date).
3) For captures of mother/pup pairs, tabulation of mother/pup pairs captured indicating: age and weight of mother; estimated age, sex, and weight of pup; type of mark (i.e., tag/transponder/radio implant), tissue samples taken, dates of capture, release, re-capture and release; date last observed; incidence and date of any mother/pup separation.
4) Tabulation of carcasses collected including gender, age class, and necropsy results.
5) A summary of observed incidents of incidental harassment during authorized activities including the animals' responses and number of animals incidentally harassed.
6) Results of necropsies performed on animals that died before or after release.
7) Discussion of any problems or complications encountered during the research.
8) Discussion of study results, including the progress made in meeting the objectives of the research as described in the application, the nature of and rationale for additional studies for upcoming year, and steps that have been or will be taken to coordinate the research activities with other sea otter researchers.
9) List of approved personnel.
10) The final report should include a summary of data analyses, results, conclusions, and copies of any published research findings.

S. If permittee desires to change study procedures from that previously described in the Permittee's file, then a letter must be submitted to DMA describing the proposed changes, and confirmation that the proposed changes fall within the authorized takes in the permit must be received from DMA prior to undertaking the procedural modifications.

T. The authorized permit activities may be extended beyond the expiration date **only** if the renewal request is received by the DMA **at least 30 days prior to the expiration of the permit** [50 CFR 13.22(c); copy attached].

SEP 13 2013

DATE

for Chief, Branch of Permits
Division of Management Authority

Permit Number: MA672624-20
Effective: 03/16/2018 Expires: 09/12/2018

Issuing Office:

Department of the Interior
U.S. FISH AND WILDLIFE SERVICE
DIVISION OF MANAGEMENT AUTHORITY
BRANCH OF PERMITS, MS: IA
5275 LEESBURG PIKE
FALLS CHURCH VA 22041-3803

Mary Cogliano
FOR
CHIEF, BRANCH OF PERMITS, DMA

Permittee:

U.S. GEOLOGICAL SURVEY
LONG MARINE LAB.
CENTER FOR OCEAN HEALTH, ROOM 152
100 SHAFFER ROAD
SANTA CRUZ, CA 95060
U.S.A.

Name and Title of Principal Officer:
JOE TOMOLEONI AND BRIAN HATFIELD - BIOLOGIST

Authority: Statutes and Regulations: 16 USC 1533 (d), 16 USC 1371 (a) (1); 50 CFR 17.32, 50 CFR 18.31.

Location where authorized activity may be conducted:
RANGE OF SOUTHERN SEA OTTERS IN CALIFORNIA WATERS

Reporting requirements:
SUBMIT COMPLETE REPORT AS REQUIRED BY CONDITION U. TO DMA AND VFWO, BY 1/31 FOLLOWING EACH YEAR PERMIT IS IN EFFECT.

Authorizations and Conditions:

A. General conditions set out in Subpart D of 50 CFR 13, and specific conditions contained in Federal regulations cited above, are hereby made a part of this permit. All activities authorized herein must be carried out in accord with and for the purposes described in the application submitted. Continued validity, or renewal of this permit is subject to complete and timely compliance with all applicable conditions, including the filing of all required information and reports.

B. The validity of this permit is also conditioned upon strict observance of all applicable foreign, state, local, tribal, or other federal law.

C. Valid for use by permittee named above. **This permit can be photocopied.**

D. Acceptance of this permit serves as evidence that the permittee understands and agrees to abide by the "General Permit Conditions" (copy attached).

E. The Permittee is authorized to take and transport up to a total of 726 southern sea otters (*Enhydra lutris nereis*) in California waters for the purpose of scientific research as described in the tables in Condition J, in Permittee's application file and conditioned below. Permittee is authorized for Level B Harassment of up to 1,290 sea otters annually from radio-tracking of instrumented sea otters by boat. Permittee is also authorized for Level B Harassment of up to 567 sea otters annually through December 31, 2017, from filming activities using remote camera and prey arrays and underwater divers, as described in the permit application file, and in accordance with the conditions below. **All photography and filming (hereafter called photography) activities must cease if harassment exceeds Level B** (see Condition Q).

F. Authorized to take and release southern sea otters of all ages and sexes as described in application including the following: Capture/, transport, immobilize, drug, hold, measure and release; flipper tag (including using "smart tags"); inject with radio-frequency identification tags; collect biological samples (see Condition J, Table 2); and surgically implant VHF transmitter/ TDR packages (and remove from same) by a veterinarian authorized under this permit. In collaboration with British Broadcasting Corporation - Ocean (MA-59492B), the Permittee is authorized to film foraging sea otters of either sex and any age class (including pups older than 3 months of age) for research purposes, including the following: filming with remotely-controlled GOPRO video camera systems semi-permanently fixed to the sea floor, making structural modifications of natural occurring habitat to control movement, and filming with a scuba dive-operated camera system.
(Conditions continue on p. 2)

United States Department of the Interior

FISH AND WILDLIFE SERVICE
International Affairs
5275 Leesburg Pike, MS: IA
Falls Church, VA 22041-3803

G. Authorized to collect salvaged specimens and carcasses and samples from the carcasses, as described in Condition J, from unlimited carcasses and salvaged remains each year.

H. Permittee must obtain all other applicable Federal, State, and local authorizations prior to initiating any research activities. Issuance of this permit does not imply that other authorizations will be granted.

I. Not authorized to incidentally harass other marine mammal species. Every effort should be made to ensure that other marine mammal species than southern sea otter are not in the immediate area prior to commencing authorized activity as described in Permittee's application and supplemental file information. Should any other marine mammal species be encountered during authorized activities, Permittee must immediately move away from the site and detour around the animals.

J. **Take Tables**:

Table 1

Authorized Takes of Live Southern Sea Otters (*Enhydra lutris nereis*), not including boat-based radio-tracking and the underwater foraging study.

	Total Take	**Anesthesia/Tag/ Tissue Sample**	**Surgery Implant/Explant**	**Incidental To Captures**
Permit Total (2013-2018)	726	406	220	100

Table 2. Samples Authorized for Collection from Captured Sea Otters or Beach-cast Remains.

Sample Type	Live/Carcass	Amount Collected	Use	Comments
Blood	Live	5% blood volume (blood volume = 8% BW	Hematology, clinical chemistry, infectious disease monitoring, biomarkers, contaminants	Blood volume "lost" from animal to include collection, loss to hematoma, bleeding from tagging, and surgical bleeding
External swabs (integument, oral cavity, rectum, genital orifice	Live	No volume limitation	Infectious disease (bacterial, fungal, parasitic, viral), contaminants, genetics	
Saliva	Live	0.3 - 1.0 ml	Hormonal assays	
Feces	Live	No limit	Diet assessment, infectious disease (bacterial, fungal, parasitic, viral), contaminants, biotoxin, hormonal assay	From environment
	Live	< 100gm		Collected from rectum
Milk	Live	< 10 ml	Nutritional content, fatty acid analysis, contaminants	May require administration of oxytocin to cause release
Urine	Live	TBD by DVM	infectious disease, toxins, urinalysis, contaminants	Free catch or cystocentesis
Adipose tissue	Both	< 10 gm (live)	Fatty acids, contaminants	May require surgical intervention with appropriate consideration for anesthesia and surgical methodology.
		No limit (dead)		
External pathology (integument, oral cavity, genital orifice)	Both	TBD by DVM	Histopathology, genetics, etiopathogenetic investigation	May require surgical intervention with appropriate consideration for anesthesia and surgical methodology.
Liver biopsies	Both	< 2 gm (live)	Histopathology, toxicology, contaminants, genetics, chemical analysis (ie, Vit A analysis)	May require surgical intervention with appropriate consideration for anesthesia and surgical methodology.
		No limit (dead)		Collected at necropsy
Premolar tooth	Both	1	Cementum aging	First upper premolar, only
Skin plugs	Both	< 2 gm (live)	Genetics	Collected in association with flipper tagging in live animals
Vibrissae	Both	2	Stable isotope	
Baculum	Carcass	1	Morphometrics, stable/radio isotopes	
Tooth	Carcass	No limit (dead)	Cementum aging	
Skull	Carcass	1 or portions	Morphometrics, stable/radio isotopes	
Fur	Both	NMT 1 gm	Hormonal assays, toxins, contaminants	Collected by plucking as not to interfere with thermoregulation.

K. **Drs. Joe Tomoleoni and Brian Hatfield are hereby designated as Principal Investigators (PI) under this permit; Jack Ames, Nancy Anderson (DVM), James Bodkin, Daniel Costa, George Esslinger, James Estes, Christine Fiorello (DVM), Heather Harris (DVM), Mike Harris, Brian Hatfield, Brent Hughes, David Jessup (DVM), Christine Kreuder-Johnson (DVM), Michael Kenner, Lesanna Lahner (DVM), Melissa Miller (DVM), Daniel Monson, Michael Murray (DVM), Seth Newsome, Michelle Staedler, Sarah McKay Strobel, Joseph Tomoleoni, Raymund Wack (DVM), Benjamin Weitzman, Terrie Williams, and Colleen Young are designated as Co-investigators. John Chambers, Sophie Morgan, Zachary Randell and Joe Stevens of BBC-Ocean are designated as Co-investigators for the underwater foraging study.** Activities under this permit may only be conducted under the on-site supervision of the PIs or Co-investigators and, as applicable, any one of the Permittee's veterinarians (Dave Jessup and Michael Murray). The Permittee may designate any other personnel as Co-investigator(s), provided the individuals have received appropriate training and possess adequate proficiency to conduct the research activities in accordance with the permit conditions. Upon designation of additional Co-investigator(s), and any additional veterinarians, the Permittee must submit the individuals' CVs to the Division of Management Authority (DMA). The names of designated Co-investigator(s) and a list of other authorized personnel must be maintained in writing by the PIs for a period of not less than 5 years and provided to DMA upon request. **Permittee and all authorized personnel must have a copy of this permit and, if applicable, all other written approvals in possession while conducting all authorized activities.** Permittee must monitor each activity conducted under this permit to ensure that authorized takes are not exceeded and that authorized and highly skilled personnel perform permitted activities.

L. **<u>Capture/Re-Capture</u>**:

1) Three attending personnel and 2 shore-based spotters must be present during all capture activities, one of which should be Permittee personnel with extensive training and previous capture/rescue experience (see K. above for co-investigator requirements).
2) Prior to initiating any field captures/re-captures for the instrumentation procedures:
   (a) Each capture and spotting team must have on-hand an up-to-date list (i.e., updated since the most recent implantation surgery) of all animals previously captured;
   (b) This up-to-date list must include each otter's radio frequency and external tag identification;
   (c) Spotters must scan all radio-frequencies of otters likely to occur in the capture area that have been implanted within the past four weeks;
   (d) If a sea otter is positively identified as having undergone surgery within the past four weeks, it may not be targeted for re-capture (unless it is being purposefully targeted as required by Cond. M.6); AND
   (e) Once a captured otter has been brought alongside the capture vessel, the radio frequency and external tag must be checked and compared to the up-to-date animal list, and if it is determined that an otter has been mistakenly re-captured, it must be released immediately at the capture location.
3) Tangle nets may not be set if weather or sea state is, or is forecast to be, such that the recovery of entangled otters may be impeded. Nets must be monitored at least every 6 hours, or every 2 to 4 hours when visibility is poor.

4) Dip nets and underwater capture methods using a diver-held trap and net bag, as described in Permittee's application, may also be used.
5) Disturbance of animals should be minimized by exercising caution when approaching and capturing animals, particularly mother-pup pairs, and the approach must be halted if there is evidence that the activity may be interfering with pair bonding, nursing, reproduction, feeding or other vital functions.
6) To minimize the chance of mother-pup separation, mother and pup should be captured together and released simultaneously following the recovery period. Dependent pups must not be targeted, unless they are targeted along with their mothers. In the event that a pup is captured and not the mother, the pup must be immediately released and allowed to reunite without sampling.
7) Every feasible effort must be made to recover and treat animals showing signs of stress, aberrant behavior, or are orphaned as a result of the permitted activities. The animals must be fully recovered prior to release to ensure that there is no post-operative bleeding. A qualified veterinarian must be consulted any time animals being held are observed shivering or otherwise appear stressed and action shall be taken based on the veterinarian's advice.
8) Captured animals must be released in the proximity of the capture location.
9) In the event that a lactating female is killed or seriously injured as a result of the activities, the female's orphaned or abandoned pup must be humanely provided for (i.e. recovered and cared for or euthanized if absolutely necessary). Such events must be reported to DMA as described in condition R. below.

M. **Instrumenting Otters**:

1) Only qualified veterinarians are authorized to surgically implant radio transmitters and TDRs; pregnant females may be radio-or TDR-tagged at the discretion of the attending veterinarian.
2) Surgically implanted animals should be returned to the same location from which they were captured.
3) To minimize the chance of mother-pup separation following surgery, only sea otters captured with their pups can be surgically implanted so both the mother and pup can be released simultaneously following the recovery period.
4) Only sea otters weighing at least 20 pounds may be instrumented.
5) Monitoring of instrumented animals should be as extensive as possible. Attempts to locate individual animals should be made at least weekly, for approximately four weeks following surgery if possible, weather permitting.
6) Every feasible effort should be made to recover and treat instrumented otters that show signs of stress or aberrant behavior or are orphaned as a result of the permitted activities. The animals must be fully recovered prior to release to ensure that there is no post-operative bleeding. A qualified veterinarian must be consulted any time animals being held are observed shivering or otherwise appear stressed, and action shall be taken based on the veterinarian's advice.
7) The number of animals which are recaptured for subsequent surgical replacement of implanted radio transmitters is as described in Condition J and the permit application file. Replacement surgery may be performed no more than one time on any given animal without additional approval from DMA, in consultation with the Marine Mammal Commission.

8) Animals which are re-captured for subsequent surgical removal of implanted radio transmitters and/or TDRs should be closely monitored as in conditions M.5 and M.6, above.

N. **Photography:** Permittee must maintain the following minimum distances from subject sea otters during all photography sessions:

APPROACH DISTANCES TO SEA OTTERS FOR THE PURPOSE OF PHOTOGRAPHY OR FILMING			
ACTIVITY OF SEA OTTER / TYPE OF APPROACH	**Resting in water**	**Swimming, traveling, diving, feeding, breeding, or nursing**	**Approaching Permittee**
Using vessels (boats, kayaks)	Maintain required minimum distance of 20 meters.	No minimum distances as long **as the behavior of sea otters is not altered** (e.g., as long as sea otters do not flee, stop feeding, or attempt to avoid closer contact). Continued pursuit of a sea otter that has fled, stopped feeding as a result of disturbance by Permittee, or attempted to avoid closer contact will violate this permit condition.	No minimum distance if Permittee remains stationary while a sea otter approaches. BUT, any effort by a sea otter to interact with Permittee or to climb onto the boat must be discouraged (e.g., by waving arms or a towel or other non-intrusive device that does not physically harm the animal, and/or by retreating).
Using dive[1] or snorkel gear[2]	No minimum distance **as long as the behavior of sea otters is not altered** (e.g., as long as sea otters do not become alert and dive). Permittee must stop approach as soon as any animal becomes alert (notices Permittee) and before it dives. Approaching resting sea otters that have become alert will violate this permit condition.	No minimum distance **as long as the behavior of sea otters is not altered (**e.g., sea otters do not flee, stop feeding, or attempt to avoid closer contact). Continued pursuit of a sea otter that has fled, stopped feeding as a result of disturbance by Permittee, or attempted to avoid closer contact will violate this permit condition.	No minimum distance if Permittee remains stationary while a sea otter approaches. BUT any effort by a sea otter to interact with Permittee must be discouraged, and Permittee must retreat if attempts at interaction continue.
On land	No required minimum distance for sea otters in water, BUT, Permittee must not make any effort to alter sea otters' behavior (e.g., by enticing with food, waving, or trying to get them to move). Approaches to hauled out sea otters must stop as soon as any animal becomes aware of human presence, i.e., notices Permittee.		

[1] Divers must use rebreather systems to minimize impacts.
[2] Divers and snorkelers must not be in the water simultaneously.

O. During all permitted photography activities of foraging sea otters, photographers must approach SSO gradually to minimize or avoid any sort of startle response. Activities must be terminated if the animals exhibit extremely evasive or high energy behaviors (see Condition Q).

1) Permittee must take extra care when conducting photography activities near mother-pup pairs and must immediately terminate efforts if there is any indication that the activity may be interfering with the mother-pup pair.
2) If any of the photography activities disrupt an otter that is feeding, breeding, or nursing, the Permittee must cease activities immediately and slowly move away from the otter.
3) If an otter moves away from the photographers, the otter must not be pursued.
4) If an otter moves away or is disturbed more than twice on a given day, the Permittee must back off and discontinue filming that otter for the remainder of the day.

P. **Film Distribution Guidelines:**

1) Permittee must provide advance copies of all media intended for the public, that in any way refers to the Service or to a Federal Agency, to the Ventura Fish and Wildlife Office (VFWO; see contact information in Condition U) for review and approval prior to any publication, distribution, or use of materials produced as a result of activities authorized under this permit. Please also see Conditions P.3 and P.4 for additional citation and disclaimer requirements.

2) Footage and photography may be used for educational and commercial purposes including, but not limited to: documentary films, DVDs, website and digital media assets (e.g. streaming video, audio clips, image library, and interactive media), photographs/prints, and other similarly related elements. Upon request, Permittee must provide DMA copies of final product.

3) All publicly released photography footage must cite the following: **"Activities authorized under U.S. Fish and Wildlife Service Permit MA672624."**

4) The following disclaimer must be added to video products:

   "The U.S. Fish & Wildlife Service is a Federal agency dedicated to conserving fish, wildlife and their habitats for the continuing benefit of the American people. As a Federal Agency we cannot endorse or oppose projects; rather we provide accurate information about the resources we have been entrusted to manage. The views expressed in this production do not necessarily represent the views of the U.S. Fish and Wildlife Service nor should any products or positions be perceived as being endorsed by the U.S. Fish and Wildlife Service."

Q. **Suspension of Activities during filming of foraging sea otters.** If the photography activities result in:

1) *"Responses by any sea otters which may indicate disturbance by disruption of behavioral patterns" ("Level B" harassment; see 672624B Attachment)* in more than five instances per day of different otter(s) or otter groups, the Permittee must contact VFWO (see contact information in Condition U) for guidance on whether and how to continue the photography activities.

2) *Taking which exceeds Level B harassment (see 672624B Attachment), the Permittee must*:
   a. Immediately discontinue all activities that resulted in the takings until reauthorized by DMA; and
   b. Report the taking within 72 hours to the Chief, DMA (phone: 1-800-358-2104; fax: 703-358-2281, e-mail: permits@fws.gov), and consult with DMA on the circumstances surrounding the taking and any precautions necessary to prevent future taking.

Based on these consultations, DMA may subsequently authorize continuation of the photography activities with any necessary modifications/conditions or initiate permit revocation procedures.

R. **In the event that ONE animal dies or is injured during or following permitted activities** and that mortality or injury can reasonably be attributed to such activities, the Permittee must immediately notify DMA (1-800-358-2104 or fax 703-358-2281 or by email) and VFWO (805-644-1766; fax: 805-644-3958) to describe the circumstances that led to the injury or mortality and to provide suggestions for measures to prevent or minimize the chances of future mortalities or injuries. DMA will have the discretion of changing permit conditions.

In the event that AN ADDITIONAL animal dies or is injured during or following permitted activities and the mortality and/or injury can reasonably be attributed to such activities:
1) Immediately suspend research activities until re-authorized by DMA;
2) Immediately notify DMA and VFWO and follow up such verbal notification with a written report detailing the circumstances that led to the injury or mortality and suggesting measures to prevent or minimize the chances of future mortalities or injuries;
3) DMA, in consultation with VFWO and the Marine Mammal Commission (MMC) may subsequently authorize continuation of the research with any necessary modifications/conditions or initiate revocation procedures.

S. **Necropsies must be performed by a qualified veterinarian**, experienced in sea otter pathology, on any animals that die during the project in order to evaluate both the long and short term effects of capture, handling, implants, etc. A copy of the necropsy report must be provided to DMA.

T. **Permittee (and authorized research collaborators) must maintain compliance with all provisions of a Registered Research Facility under the Animal Welfare Act** as required by the U.S. Department of Agriculture, Animal and Plant Health Inspection Service. Upon expiration of Permittee's Institutional Animal Care and Use Committee (IACUC) approval, documentation of an extension of this approval must be provided to DMA.

U. **Annual Reporting Requirements:** In accordance with block 12 of this permit, copies of an Annual Report of the previous year's activities must be submitted by January 31 to: 1) DMA at Permits@fws.gov (Reference "Annual Report for MA672624" in Subject Line) and 2) to the Ventura Fish and Wildlife Office , 2493 Portola Road, Suite B, Ventura, CA 93003, with an electronic cc to Lilian_Carswell@fws.gov. The Annual Report shall include at a minimum the following:

1) A summary of research activities conducted, including locations and dates of filming.
2) For captures, tabulation of sea otters (tabulate mother/pup pairs as in 3. below) captured indicating: age, sex, weight, type of mark (i.e. tags), tissue samples taken, dates of capture and release and date last observed (if observed since release date).
3) For captures of mother/pup pairs, tabulation of mother/pup pairs captured indicating: age and weight of mother; estimated age, sex, and weight of pup; type of mark (i.e., tag/transponder/radio implant), tissue samples taken, dates of capture, release, re-capture and release; date last observed; incidence and date of any mother/pup separation.
4) Tabulation of carcasses collected including gender, age class, and necropsy results.
5) A tabulation of all sea otters filmed, the equipment used to photograph, distances that were maintained between subject sea otters and equipment used, and the distance of "threshold" disturbance.
6) A summary of observed incidents of incidental harassment during authorized activities including the animals' responses and number of animals incidentally harassed.
7) Results of necropsies performed on animals that died before or after release.
8) Discussion of any problems or complications encountered during the research.
9) Discussion of study results, including the progress made in meeting the objectives of the research as described in the application, the nature of and rationale for additional studies for upcoming year, and steps that have been or will be taken to coordinate the research activities with other sea otter researchers.
10) A list of final and planned products.
11) List of approved personnel.
12) The final report should include a summary of data analyses, results, conclusions, and copies of any published research findings.

V. **If Permittee desires to change study procedures** from that previously described in the Permittee's file, then a letter must be submitted to DMA describing the proposed changes. Confirmation that the proposed changes fall within the authorized takes in the permit must be received from DMA prior to undertaking the procedural modifications.

W. **The authorized permit activities may be** extended beyond the expiration date **only** if the renewal request is received by DMA **at least 30 days prior to the expiration of the permit** [50 CFR 13.22(c)].

MAR 16 2018

DATE

FOR Chief, Branch of Permits
Division of Management Authority

Attachment: [672624 Attachment]

Vargas, Darcy <darcy_vargas@fws.gov>

2017 Sea otter Permit report (Permit # 672624)

Tomoleoni, Joseph <jtomoleoni@usgs.gov> Wed, Jun 26, 2019 at 7:01 PM
To: Darcy Vargas <darcy_vargas@fws.gov>

Hi Darcy,

Our 2017 permit report is attached here. I am having trouble locating the 2016 permit report, as I was not the permit holder during this time. The permit holder in 2016 (Tim Tinker) left USGS in 2017 and now resides in another country. I do know that our annual permit reports were all submitted without missing any years, so DMA should have all our prior reports. I've still attached the 2017 report here, since I happen to have a copy, but locating the a copy of the 2016 report could be a challenge since I wasn't the permit holder in 2016.

Thank you,

Joe
--
Joe Tomoleoni
Biologist
U.S. Geological Survey
Western Ecological Research Center
Santa Cruz Field Station
2885 Mission St.
Santa Cruz, CA 95060
office: 831.460.7447
cell: 831.254.9750
jtomoleoni@usgs.gov

2017 ANNUAL REPORT ON SEA OTTER.pdf
14987K

ANNUAL REPORT ON SEA OTTER (Enhydra lutris) RESEARCH CONDUCTED UNDER PERMIT MA672624-18 DURING 2017

30 January 2018

TO: US Fish & Wildlife Service
Division of Management Authority
Branch of Permits
4401 North Fairfax Dr., Room 212
Arlington, Virginia 22203

US Fish & Wildlife Service
Ventura Field Office
2493 Portola RD., Suite B
Ventura CA 93003

PERMITTEE: Tim Tinker, Research Wildlife Biologist
Brian Hatfield, Biologist
Joseph Tomoleoni, Biologist
U.S. Geological Survey – Western Ecological Research Center
Long Marine Laboratory, UC Santa Cruz
115 McAllister Way
Santa Cruz, California 95060

SECTION 1: CAPTURE, MARKING, MORTALITY, AND INCIDENTAL HARASSMENT

Capture and Marking Summary All capture and marking of sea otters was done according to methods described in the most recent amended/renewed version for Permit PRT MA672624. No problems or complications were encountered during the capture, handling, tagging or tracking of the captured sea otters in 2017.

There were 8 sea otters captured under this permit in 2017. Five adult females and 3 aged adult females were captured. Four of the sea otters had been captured in previous years (Table 1).

All of the captured sea otters received flipper tags (either for the first time or for the replacement of lost ones) under this permit in 2017. Only two of the captured sea otters underwent surgery in 2017. These two surgeries were for the implantation of radio transmitters. No time-depth-recorder (TDR) implants were done in 2017. Each of the 4 sea otters captured for the first time in 2017 received a transponder chip. A pre-molar tooth was extracted from 1 sea otter and blood samples were taken from all 8 captured animals (Table 2).

All 8 sea otters were captured using the diver held trap (Wilson trap) off the Monterey Peninsula. There were no mortalities of study animals that were captured in 2017 under this permit (by mid-January 2018). All 8 sea otters captured in 2017 are being seen/tracked regularly off the Monterey Peninsula (as of mid-January 2018, Table 1).

Mortality of Implanted Sea Otters Ten sea otters captured under this permit and implanted/explanted with a TDR and/or a radio transmitter were recovered dead in 2017. None of the 10 had undergone surgery in 2017. Four of the eleven died within a year after surgery. The two sea otters that died within 250 days of surgery both succumbed to shark bite (BRD1360 and BRD1362). One (BRD1364) stranded 268 days after surgery and died as a result of a *Sarcocystis* protozoal infection. The final sea otter that died within a year post-surgery died of unknown cause(s) (BRD1354). The remaining 7 animals stranded at least 400 days after surgery. The most common cause of death among these 10 sea otters was shark bite. In an unusual event, one study animal was likely struck by a train in Elkhorn Slough (Table 4). Stranded Sea Otter Fact Sheets with final or preliminary necropsy findings for those that were necropsied are included as attachments to this report.

Mortality of Non-Implanted Sea Otters Five sea otters that were captured under our permit in previous years that had never undergone surgical procedures were recovered dead in 2017 (Table 5). Four of 5 were necropsied and the reports are attached.

Incidental Harassment. During wild sea otter captures using the diver held trap (Wilson trap – the only method used in 2016), other sea otters that are resting near the captured otters are incidentally harassed. When the Wilson trap hits the surface, sea otters that are not the intended targets but are within approximately 10 – 15 meters, are usually startled, immediately dive and swim away. We do not or cannot determine the exact sea otter raft size at each capture, but our observational database on tagged study animals (based on 55,000 tagged otter re-sightings collected during recent years) indicates that average resting group size in California is 4.3 otters (standard deviation =4.96, data are log-normally distributed). We made 6 capture runs using Wilson traps during which sea otters were captured in 2017, for which the 95% confidence interval for estimated mean group size (assuming 6 groups of random size) is 2.5–6.7. For each capture run we successfully capture 1.2 animals on average, so excluding captured animals our estimated number of otters incidentally harassed during all Wilson trap capture events is 19, with 95% confidence interval 8 - 33.

SECTION 2: RESEARCH GOALS AND PROGRESS MADE IN 2017

Excellent progress was made during our only tracking study, located on the Monterey Peninsula, in 2017. The Monterey Project was initiated in June 2016 as part of a larger NSF-funded study to examine the effects of predator diversity on the stability and resilience of kelp forest ecosystems in the face of an ongoing epidemic that has caused coast-wide losses of key sea star species. Southern sea otters were tagged and monitored in order to examine the extent to which they might be able to compensate for the declines in sea stars, another important predator of invertebrates in kelp forests. Data collection on the Monterey project is slated to continue through 2018 with a projected end date of summer of 2019. In 2017 our tracking efforts were very robust, with daily or near daily efforts to locate each study animal. The total tracking effort includes time dedicated to the collection of foraging data as well as other more general objectives relevant to sea otter biology and conservation (see Annual Permit Report for 2016). During 2017 a total of 5,646 resights were collected and entered by field personnel in the Monterey Peninsula study area. Since the beginning of the project, 9,937 resights have been made on our study animals. Although a total of 10 radio-implanted sea otters were recovered dead this year, 5 were from the Monterey Peninsula study. This brings the total number of confirmed deceased study animals to 7 since the start of the Monterey Peninsula study. Of the 5 study animals that died in 2017, 2 were victims of shark bite, 1 died of a systemic *Sarcocystis neurona* infection, and the final 2 mortalities were of unknown cause. The cause of death and mortality information for all 10 deceased sea otters are referenced earlier in this report (see the Morality of Implanted Sea Otters section and Tables 3 and 4).

Since the beginning of the Monterey Peninsula study in June 2016, a total of 19 pups have been born to study animals. Of those 19 pups, 10 have been weaned successfully while only 4 pups did not survive until weaning. The remaining 5 pups have not yet reached weaning age, and thus, are still dependent on their mothers as of January 2018. A total of 4 time-depth recorders have been recovered from these stranded animals since the start of the project. No efforts have been made to re-capture and explant time-depth recorders so far, but there will be multiple recapture efforts in the next 12-18 months that will aim to recover as many time-depth recorders as possible.

In September of 2017, two days of sea otter captures were conducted in Monterey between the Monterey Harbor and Otter Point, as referenced earlier in this report (see Capture and Marking Summary and Table 1). These captures served a dual purpose: (1) to add new otters to the study, correcting our decreased sample size due to relatively high natural mortality in the previous year and (2) to recapture previously tagged study animals that had chewed off one or both flipper tags, so that new tags could be placed on the otters and facilitate their monitoring throughout the study. Of the 8 captured otters in September 2017, two were implanted with VHF radio transmitters and were added to the long term Monterey study. The remaining 6 otters all received flipper tags so that they could be identified post-capture and resighted opportunistically, but since they cannot be located via VHF radio telemetry, they are not considered to be reliable study animals for regular data collection.

Our progress on the collection of foraging data has been excellent since the beginning of the Monterey Peninsula study, and that productivity has continued through 2017. To date, a total of 18,271 individual foraging dives and 988 distinct foraging bouts have been recorded during this study. Of those totals, 10,109 dives (55% of total) and 614 bouts (62% of total) were recorded in 2017. Mussels and sea urchins continue to dominate the diet in the sea otters of the Monterey Peninsula, together accounting for about 65% of the total prey items consumed. Crabs, snails, and abalone round out the mostly commonly consumed prey species, each accounting for more than 5% of the sea otter diet (Figure 1).

In 2018 we anticipate the continuation of data collection on the Monterey Peninsula NSF study with daily data collection throughout the year. At this time there are no plans for another large scale capture effort to initiate any new studies in 2018, however, there will likely be several smaller scale (1-2 day) re-capture efforts in Monterey that aim to both (1) replace chewed-off tags with new tags and (2) recover previous implanted time-depth recorders. As previously mentioned in several past permit reports, progress continues to be made on new tagging technologies for the future of sea otter monitoring. Multiple avenues are being pursued, but the one that holds the most promise involves the collaboration between USGS WERC researchers (both sea otter and bird biologists who have a mutual interest in miniaturized tags that employ new technologies) and NASA Ames researchers that have the engineering expertise to design new tags. We are encouraged by the progress made so far, and are hoping to have a prototype "smart" flipper tag ready for deployment at some point in 2018. The new flipper tags could have the ability to obtain GPS locations. We are also hoping that these new tags will have networking capabilities that allow sea otters to resight each other, providing us with a wealth of previously unknown data on interaction strengths. Prototypes will first be tested on captive sea otters at the Monterey Bay Aquarium under their existing permit. Further communication with the permit office will occur once we deem the tags ready for field deployment on wild sea otters to ensure that all necessary permissions have been obtained. It should be noted, however, that the implantation of sub-cutaneous transmitter tags is already covered in both our Federal permit and our existing IACUC permit with UC Santa Cruz, and the development of a smart flipper tag is even less invasive (and thereby less risky) than a sub-cutaneous tag, which was already less invasive than our current intra-abdominal implants.

In 2017, with support from the U. S. Navy, we expanded our on-going sea otter work at San Nicolas Island. We increased our island-wide sea otter surveys from twice annually, to 4 times per year. This more robust research effort also includes the collection of foraging data on untagged sea otters at San Nicolas Island, the first effort to examine sea otter diet and resource abundance at this location in over a decade. The research plan for this study consists of 3 tiers of monitoring. For all of 2017, and at present time in 2018, we are at the Tier 1 level, which mandates that we conduct 4 surveys per year, and collect as much foraging data as possible during these field trips. If, during the course of our study we discover that: (1) a single dead, moribund, or stranded sea otter is found with injuries consistent with impacts from Navy activities or (2) the sea otter population at San Nicolas Island decreases by more than 10% from the average trend of the preceding 3-year period for at least 2 consecutive years or (3) the total population of sea otters at San Nicolas Island drops below 75 individuals, the level of research would be elevated to Tier 2 or Tier 3. Tier 2 requires additional operational monitoring for any new military readiness activities with the potential to impact sea otters or their habitat. If conditions exist that require the research to be elevated to Tier 3, this would involve advanced monitoring of the sea otter population, and would require the capture, tagging, and instrumentation of approximately 25 sea otters at San Nicolas Island, with intensive and regular monitoring of the tagged animals post-release.

Finally, at the end of 2017 the primary permit holder, Tim Tinker, left his position with the U. S. Geological Survey. As a result of discussions with the U. S. Fish & Wildlife Service, it was determined that the new primary permit holders would be listed as Joseph Tomoleoni and Brian Hatfield (both with USGS), and that Tim Tinker would remain on the permit as a co-investigator, but no longer as the primary permit holder.

Individuals permitted to handle otters:

M. Tim Tinker

Jack Ames

Nancy Anderson

James Bodkin

Dan Costa

George Esslinger

James Estes

Christine Fiorello

Heather Harris

Mike Harris

Brian Hatfield

Brent Hughes

David Jessup

Christine Kreuder-Johnson

Michael Kenner

Lesanna Lahner

Melissa Miller

Daniel Monson

Michael Murray

Seth Newsome

Zachary Randell

Michelle Staedler

Joseph Tomoleoni

Raymund Wack

Benjamin Weitzman

Terrie Williams

Colleen Young

Additional Tracking Personnel not listed on permit:

Gena Bentall

Sarah Chinn

Sarah Espinosa

Jessica Fujii

Nicole LaRoche

Sophia Lyon

Teri Nicholson

TABLE 1. Summary of sea otters captured in California under Permit MA672624 in 2017.

OTTER NO.	CAPTURE DATE	LOCATION	SEX	AGE	WT (kg)	LENGTH (cm)	TX	FUNCTIONING TRANSMITTER?	STATUS (as of mid-Jan 2018)
BRD1111-09-5	26-Sep-17	Monterey Peninsula	F	AA	22.6	119.0	none	No	Frequently Resighted
BRD1171-11-3	26-Sep-17	Monterey Peninsula	F	AA	21.6	118.0	yes	166.142	Frequently Resighted
BRD1329-14-2	26-Sep-17	Monterey Peninsula	F	A	24.9	122.0	has existing	165.709	Frequently Resighted
BRD1374-17	26-Sep-17	Monterey Peninsula	F	AA	19.8	123.0	none	No	Frequently Resighted
BRD1173-11-2	27-Sep-17	Monterey Peninsula	F	A	22.1	113.5	none	No	Frequently Resighted
BRD1375-17	27-Sep-17	Monterey Peninsula	F	A	18.8	115.5	yes	167.655	Frequently Resighted
BRD1376-17	27-Sep-17	Monterey Peninsula	F	A	25.0	117.0	none	No	Frequently Resighted
BRD1377-17	27-Sep-17	Monterey Peninsula	F	A	25.4	121.5	none	No	Frequently Resighted

Table 2. Marks applied to and samples taken from sea otters captured in California under Permit MA672624 in 2017.

OTTER BRD NO	CAPTURE DATE	R TAG COLOR	L TAG COLOR	TRANSPONDER NUMBER	RADIO TRANSMITTER	TDR IMPLANT	SAMPLES COLLECTED: TOOTH	BLOOD	TISSUE PLUG	LIVER BIOPSY	HAIR	WHISKER	FAT	SWABS/SMEARS: BUCCAL	ANAL	NASAL	SALIVA
1111-09-5	26-Sep-17	PI	WH	has existing	NA	N	N	Y	N	N	Y	Y	N	Y	Y	Y	N
1171-11-3	26-Sep-17	WH	RE	has existing	166 142	N	UR	Y	Y	N	Y	Y	N	Y	Y	Y	N
1329-14-2	26-Sep-17	PI	PI	has existing	has existing	N	N	Y	Y	N	Y	Y	N	Y	Y	Y	N
1374-17	26-Sep-17	YE	LB	985141000930530	NA	N	N	Y	Y	N	Y	Y	N	Y	Y	Y	N
1173-11-2	27-Sep-17	RE	CH	has existing	NA	N	N	Y	N	N	Y	Y	N	Y	Y	Y	N
1375-17	27-Sep-17	YE	WH	985141000930450	167 655	N	N	Y	Y	N	Y	Y	N	Y	Y	Y	N
1376-17	27-Sep-17	YE	RE	985141000930545	NA	N	N	Y	Y	N	Y	Y	N	Y	Y	Y	N
1377-17	27-Sep-17	YE	CH	985141000929925	NA	N	N	Y	Y	N	Y	N	N	Y	Y	Y	N

TABLE 3. Surgically implanted sea otters captured under Permit MA672624 that died in 2017. Sea otters listed by recovery date.

Otter No.	SO#	Age/Sex	Date of Last Surgery	Date Recovered	No. Days Since Last Surgery	Condition	Capture Wt. (kg)	Stranding Wt. (kg)	Primary Cause(s) of Stranding
BRD1360	8246-17	Adult Male	3-Jun-16	1-Jan-17	212	fresh	29.4	26.1	shark bite
BRD1362	8273-17	Adult Female	3-Jun-16	24-Jan-17	235	fresh	18.8	17.7	shark bite
BRD1312-13	8289-17	Adult Male	19-Sep-13	6-Feb-17	1236	advanced decomp.	26.3	36.4	Consistent with struck by train
BRD1364-16	8322-17	Sub-Adult Female	6-Jun-16	1-Mar-17	268	fresh	13.0	11.5	Sarcocystis
BRD1297-13	8381-17	Adult Male	17-Sep-13	4-Apr-17	1295	fresh	28.7	30	likely domoic acid intox., cardiomyopathy
BRD1341-15	8403-17	Adult Female	13-Apr-15	16-Apr-17	734	mummified	21.3	-	unknown
BRD1328-14	8443-17	Aged Adult Male	23-Sep-14	12-May-17	962	fresh	34.1	28.5	shark bite
BRD1354-16	8447-17	Adult Female	2-Jun-16	15-May-17	347	fresh	15.4	15.8	unknown, no trauma
BRD1337	8455-17	Adult Female	13-Apr-15	22-May-17	770	moderate decomp.	21.5	17.7	domoic acid intoxication likely
BRD880	8576-17	Aged Adult Female	1-Oct-02	5-Aug-17	5422	advanced decomp.	18.7	16.6	unknown, no trauma
BRD1366	8646-17	Adult Female	6-Jun-16	1-Oct-17	482	advanced decomp.	20.2	-	unknown

TABLE 4. Non-implanted sea otters captured under Permit MA672624 that died in 2017. Sea otters listed by recovery date.

Otter No.	SO#	Age/Sex	Date Last Captured	Date Recovered	No. Days Since Last Capture	Condition	Capture Wt. (kg)	Stranding Wt. (kg)	Primary Cause(s) of Stranding
BRD1336-14-2	8254-17	Adult Female	1-Jun-16	5-Jan-17	218	fresh	24.0	22.9	cardiomyopathy, hepatic thrombus
BRD999-05-3	8385-17	Aged Adult Female	2-Jul-15	8-Apr-17	646	fresh	16.8	12.6	emaciation, cardiomyopathy, old age
BRD1260	8458-17	Adult Female	18-Oct-12	23-May-17	1678	advanced decomp.	19.2	12.5	end lactation syndrome
BRD1352-16	8564-17	Sub-Adult Male	2-Jun-16	1-Aug-17	425	mummified	12.8	-	unknown, no trauma
BRD1314-13	8606-17	Adult Female	10-Dec-13	26-Aug-17	1355	fresh	20.2	21.5	shark bite

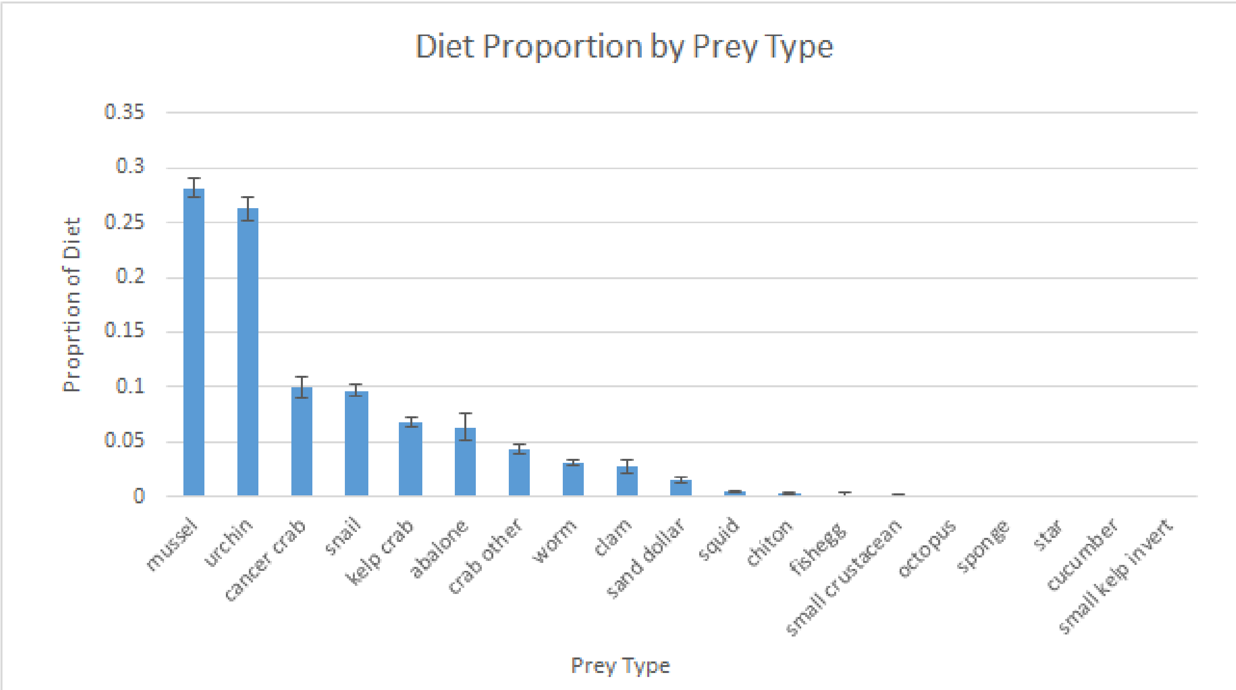


Figure 1. Percent of prey types consumed by sea otters in the current Monterey Peninsula study.

BRD 1360-16

STRANDED SEA OTTER FACT SHEET

SO# 8246-17

PERSON REQUESTING SO#: Karl Mayer

DATE FOUND: 01 (DD) JAN (MMM) 2017 (YYYY)

MWVCRC# 17-0001, MBA#757-17

FOUND BY: PC RPC BO PM SBS SOB BIO UU

OTHER# BRD-1360-16, 1750,001

RECOVERY AREA: 13 **ATOS:** 375 **LAT / LONG (DD):** N W **TC / GE**

RECOVERY LOCATION: Monterey, Del Monte Beach (CITY / COUNTY; LOCATION DETAILS, LANDMARKS) **TAR ON BEACH:** N / Y / ?

COND: 1=ALIVE 2= FRESH 3=MOD DECOMP 4=ADV DECOMP 5=MUMM/FRAG/SKEL 9=? EUTH: Y / N **SCAVENGED:** 0=NO 1= SLIGHT 2=MOD 3=HEAVILY 9=?

SEX: F / M / ? **AGE:** 2=PUP 3=IM 4 or 14 =SA 5 or 15=AD 6=AGED AD 7=PUP OR IM 8=SA, AD, AA 9=?

TAGGED: N / Y / ? (Y=PG 2) **TAR ON OTTER:** N / Y / ? **OBV TRAUMA:** N / Y / ? **EST AGE:** 5-7 W / M / YR **BY:** Miller

TL: 133 CM MBA **TAIL:** 31.2 CM MBA 29.0 CDFW - hard rigor **WT:** 26.1 KG MBA 26.4 CDFW (wet wt) **NOSE WOUND:** SIZE: S FRESHNESS: W

TEETH: 5=ALL MILK 6=SOME MILK 1=EXC 2=GOOD 3=FAIR 4=POOR 9=? REMARKS:

ECHINO: 0=NONE 1=SLIGHT 2=OBVIOUS 9=? (SKULL OR PCS EXAMINED, SEE BACK) REMARKS:

GRIZZLE: 6=NATAL 7=JUV BUFF 1=NONE TO SLIGHT 2=TO EYES 3=TO LAMBDOIDAL CREST 4=TO CHEST 5=TO TAIL 9=?

RED ALGAE ON FUR: N / Y / ? VISUAL / UV LAMP 1=< 2% 2=2-10% 3=11-20% 4=>20% REMARKS:

NECROPSY: NO / F / G / D BY WHOM: B / BP / V / VP / P Miller, Batac, Dodd, Greenwald DATE: 3 Jan 2017

COND AT NEC: 2 / 3 / 4 / 5 **PREV FROZEN:** N / Y **LOCATION OF NECROPSY:** MWVCRC

SUBCU FAT: 0=NONE 1=SCANT 2=FAIR 3=MOD 4=ABUND 9=? **TARRY DIGESTA:** 0=NOT OBVIOUS 1=SLIGHT 2=OBVIOUS 9=?

FOOD IN GUT: 0=EMPTY 1=LITTLE 2=MED 3=FULL 9=? PREY:

ACANTH: UNK / NO / C / P / C=P / CP / PC INT: 0=NONE 1=MILD 2=MOD 3=HEAVY 9=? AB: 0=NONE 1=MILD 2=MOD 3=HEAVY 9=?

FETUS: N=NO Y=YES, NO SEX M=YES, MALE F=YES, FEMALE U=? TL: ____ CM CR: ____ CM WT: ____ GM

WOUNDS CHARC OF SHARK BITE: N / Y / ? **EFFORT TO CONFIRM:** 0=NONE 1=CURSORY 2=INTENSIVE 3= NA

WOUND DESCR: 1=NO OBVIOUS HEALING 2= INDICATION OF HEALING 3= INDICATION OF INFECTION 4= OBVIOUSLY OLD, HEALED 5= ? 6=NA

EVIDENCE WOUNDS ANTE-MORTEM: Y / ? / NA IF YES: SQ HEM OTHER:

REMARKS:
Significant fresh shark trauma to both dorsum and ventrum. Moribund upon rescue.

TDR ; VHF recovered

PREMOLAR: N / UR UL LR LL **FUR:** N / Y **WHISKERS:** N / Y **OTHER SAMPLES:** N / Y (Y=SEE BACK) **PHOTOS:** N / Y

CAUSE OF STRANDING: 5 **IF CODE=10 OR 11, THEN PRIMARY:**

OTHER SIGNIFICANT FINDINGS:

DISPOSITION: CARCASS: 0 PELT: 0 SKELETON: 0 SKULL: 0 BACULUM: 0 PREMOLAR: 192 (192)

CONTINUE ON BACK: N / Y

FACTSHEET2016_V1

SO# 8246-17

BRD
TAG REF #: 1360 **KNOWN AGE:** N / Y **IF YES:** KA<3 MO KA<6 MO KA< 12MO

TAGS: R: TQ / 4/5 / mba 384 (COL / POS / NO; MISSING? Y / N) **L:** RB / 1/2 / mba 055 (COL / POS / NO; MISSING? Y / N) **PIT:** 985141000930625 **WORKING:** Y / N / ? R

TAG HX:
Captured once in Monterey on 6/2/2016. TDR and VHF

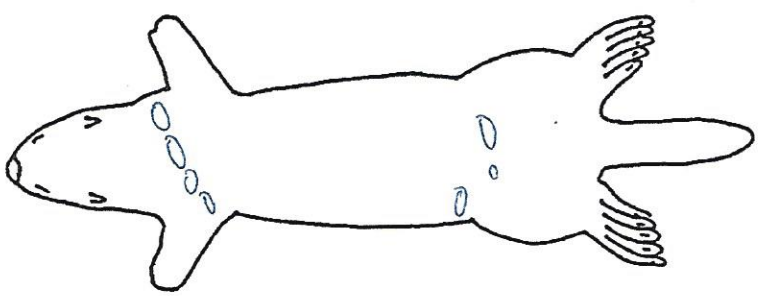
ECHINO: SKULL: 0=NONE 1=SLIGHT 2=OBVIOUS 9=? **PCS:** 0=NONE 1=SLIGHT 2=OBVIOUS 9=? REMARKS:

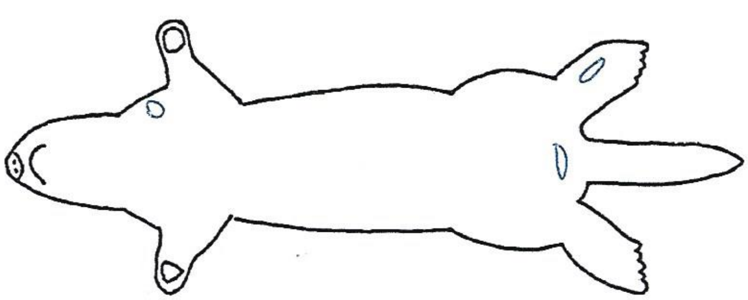
SAMPLES TAKEN: BI=BILE BL=BLOOD BR=BRAIN GC=GUT CONTENT HE=HEART KI=KIDNEY LI=LIVER LN=LYMPH NODE LU=LUNG MU=MUSCLE SP=SPLEEN UR = URINE ALL OTHER:
FOR WHAT: WHOM:

HISTO SAMPLE: FULL / PARTIAL

XRAY: 1=YES,GUNSHOT 2=YES,NOT GUNSHOT 3=YES,GUNSHOT:OLD HEALED WOUND

ADDITIONAL REMARKS:





BRD 1362-16

STRANDED SEA OTTER FACT SHEET

SO# 8273-17

PERSON REQUESTING SO#: K. Mayer

DATE FOUND: 24 (DD) Jan (MMM) 2017 (YYYY)

MWVCRC# 17-0019, 1750057

FOUND BY: PC RPC BO PM SBS SOB BIO UU — MBA Guest Experience Staff

OTHER# N-1638-16-S, BRD 1362-16

RECOVERY AREA: 14 **ATOS:** 380 **LAT / LONG (DD): N** 36.617268 **W** -121.900696 **TC / GE**

RECOVERY LOCATION: Clement Hotel, Cannery Row, Monterey (CITY / COUNTY; LOCATION DETAILS, LANDMARKS) **TAR ON BEACH:** N / Y / ?

COND: 1=ALIVE (EUTH: Y / N) 2=FRESH 3=MOD DECOMP 4=ADV DECOMP 5=MUMM/FRAG/SKEL 9=?

SCAVENGED: 0=NO 1=SLIGHT 2=MOD 3=HEAVILY 9=? — LIKELY AUTOPHAGY-DDX ANTEMORTEM SCAVENGING SEE REPORT

SEX: F / M / ? **AGE:** 2=PUP 3=IM 4 or 14 =SA 5 or 15=AD 6=AGED AD 7=PUP OR IM 8=SA, AD, AA 9=?

TAGGED: N / Y / ? (Y=PG 2) **TAR ON OTTER:** N / Y / ? **OBV TRAUMA:** N / Y / ? **EST AGE:** 4-5 W / M / YR **BY:** MM

TL: 116.5 CM **TAIL:** 30.0 CM **WT:** 17.7 KG **NOSE WOUND:** SIZE: S FRESHNESS: W

TEETH: 5=ALL MILK 6=SOME MILK 1=EXC 2=GOOD 3=FAIR 4=POOR 9=? REMARKS:

ECHINO: 0=NONE 1=SLIGHT 2=OBVIOUS 9=? (SKULL OR PCS EXAMINED, SEE BACK) REMARKS:

GRIZZLE: 6=NATAL 7=JUV BUFF 1=NONE TO SLIGHT 2=TO EYES 3=TO LAMBDOIDAL CREST 4=TO CHEST 5=TO TAIL 9=?

RED ALGAE ON FUR: N / Y / ? VISUAL / UV LAMP 1=< 2% 2=2-10% 3=11-20% 4=>20% REMARKS:

NECROPSY: NO / F / G / D BY WHOM: B / BP / V / VP / P MM, ED, FR, AMR **DATE:** 26 Jan 2017

COND AT NEC: 2 / 3 / 4 / 5 **PREV FROZEN:** N / Y **LOCATION OF NECROPSY:** MWVCRC

SUBCU FAT: 0=NONE 1=SCANT 2=FAIR 3=MOD 4=ABUND 9=? **TARRY DIGESTA:** 0=NOT OBVIOUS 1=SLIGHT 2=OBVIOUS 9=?

FOOD IN GUT: 0=EMPTY 1=LITTLE 2=MED 3=FULL 9=? (for what was left) PREY: N/A part of intestines missing

ACANTH: UNK / NO / C / P / C=P / CP / PC INT: 0=NONE 1=MILD 2=MOD 3=HEAVY 9=? AB: 0=NONE 1=MILD 2=MOD 3=HEAVY 9=?

FETUS: N=NO Y=YES, NO SEX M=YES, MALE F=YES, FEMALE U=? TL: ____ CM CR: ____ CM WT: ____ GM

WOUNDS CHARC OF SHARK BITE: N / Y / ? **EFFORT TO CONFIRM:** 0=NONE 1=CURSORY 2=INTENSIVE 3= NA

WOUND DESCR: 1= NO OBVIOUS HEALING 2= INDICATION OF HEALING 3= INDICATION OF INFECTION 4= OBVIOUSLY OLD, HEALED 5= ? 6=NA

EVIDENCE WOUNDS ANTE-MORTEM: Y / ? / NA IF YES: SQ HEM OTHER:

REMARKS:
Two large parallel lacerations on abdomen, evisceration of intestines. First observed while still alive off MBA, but died a short time later. Supposed to have a TDR.

POSSIBLE ANTEMORTEM AUTOPHAGY

MULTIPLE HOLES IN STOMACH PANCREAS MESENTERY INTESTINES W/ ASSOC. HEMORRHAGE

TDR + OMENTUM MISSING
VHF MISSING
MUCH OF SI MISSING

PREMOLAR: N / UR UL LR LL **FUR:** N / Y **WHISKERS:** N / Y **OTHER SAMPLES:** N / Y (Y=SEE BACK) **PHOTOS:** N / Y

CAUSE OF STRANDING: 5 **IF CODE=10 OR 11, THEN PRIMARY:**

OTHER SIGNIFICANT FINDINGS:

DISPOSITION: CARCASS: 0 PELT: 0 SKELETON: 0 SKULL: 102 BACULUM: 0 PREMOLAR: 192

FACTSHEET2016_V1

CONTINUE ON BACK: N / Y

8525 - eye saved [illegible]

SO# 8273-17

TAG REF #: BRD 1362-16 **KNOWN AGE:** (N) / Y **IF YES:** KA<3 MO KA<6 MO KA< 12MO

TAGS: R: TQ / 1/2 / MBA 368 (MISSING? Y / N ✓) **L:** * HO / 4/5 / (MISSING? ✓ / N) **PIT:** 985141000930623 **WORKING:** (Y) / N / ?

COL POS NO COL POS NO

TAG HX:
TDR# 1690052. Has R TQ 1/2 (MBA 368), but L tag is missing, and *could not find evidence of flipper tag hole (supposed to be L HO 4/5). Captured June 2016, last resight 14-Jan-2017.
likely shed L tag soon after tagging – MM

ECHINO: SKULL: (0=NONE) 1=SLIGHT 2=OBVIOUS 9=? **PCS:** 0=NONE 1=SLIGHT 2=OBVIOUS 9=? REMARKS:

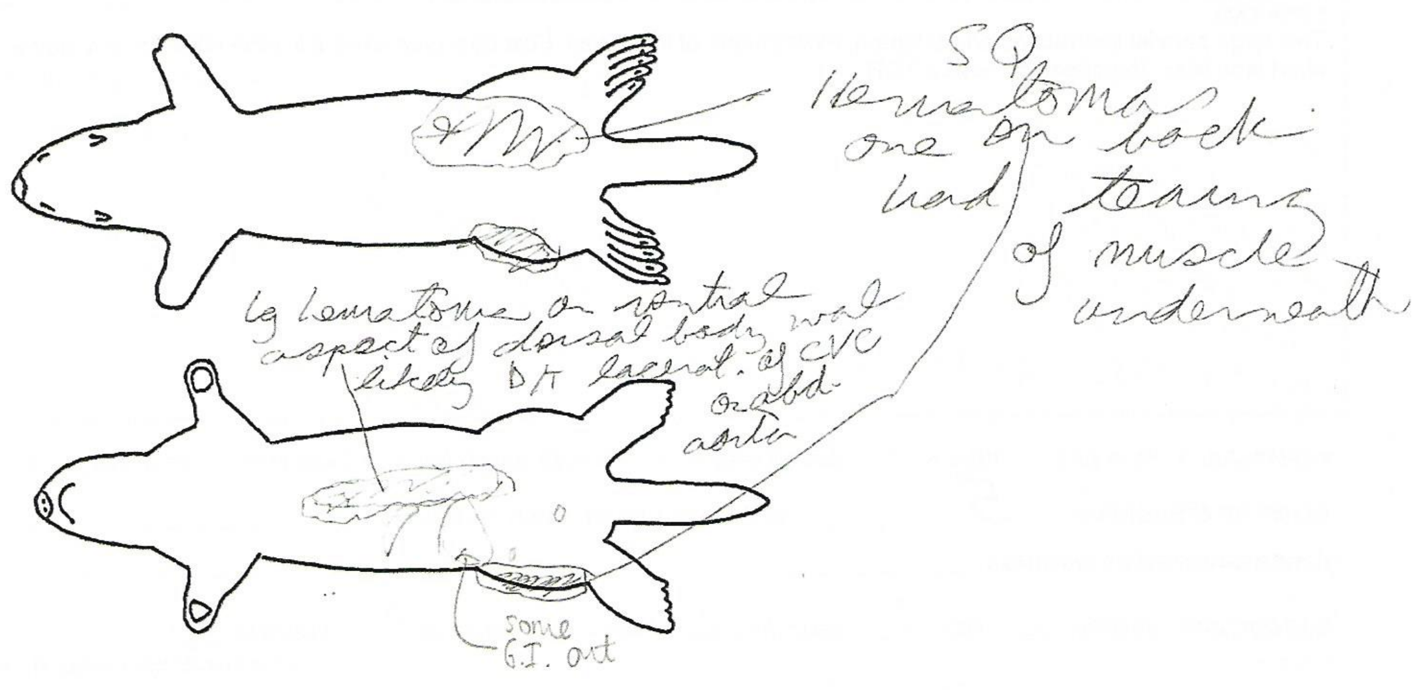
SAMPLES TAKEN: BI=BILE BL=BLOOD BR=BRAIN GC=GUT CONTENT HE=HEART KI=KIDNEY LI=LIVER LN=LYMPH NODE LU=LUNG MU=MUSCLE SP=SPLEEN UR = URINE (ALL) OTHER:
FOR WHAT: Full case WHOM:

HISTO SAMPLE: (FULL) / PARTIAL

~~**XRAY:**~~ 1=YES,GUNSHOT 2=YES,NOT GUNSHOT 3=YES,GUNSHOT:OLD HEALED WOUND

ADDITIONAL REMARKS:

8 young adult female
(basi-occipital physis closed)
– no prior pregnancies. appears
to be in first estrus (lg follicle).
Repro stage 0/5



STRANDED SEA OTTER FACT SHEET

SO# 8289-17

PERSON REQUESTING SO#: Sandrine Hazan

DATE FOUND: 6 (DD) Feb (MMM) 2017 (YYYY)

MWVCRC# 17-0021

FOUND BY: PC RPC BO PM SBS SOB BIO UU Mike Foster

OTHER# BRD 1312-13, 17S0090

RECOVERY AREA: 12 **ATOS:** 321B **LAT / LONG (DD): N** 36.8087 **W** 121.7467 **TC / GE**

RECOVERY LOCATION: Elkhorn Slough, found on the tracks between Yampah and Avila (CITY / COUNTY; LOCATION DETAILS, LANDMARKS) **TAR ON BEACH:** N / Y / ?

COND: 1=ALIVE 2= FRESH 3=MOD DECOMP 4=ADV DECOMP 5=MUMM/FRAG/SKEL 9=? EUTH: Y / N **SCAVENGED:** 0=NO 1= SLIGHT 2=MOD 3=HEAVILY 9=?

SEX: F / M / ? **AGE:** 2=PUP 3=IM 4 or 14 =SA 5 or 15 =AD 6=AGED AD 7=PUP OR IM 8=SA, AD, AA 9=?

TAGGED: N / Y / ? (Y=PG 2) **TAR ON OTTER:** N / Y / ? **OBV TRAUMA:** N / Y / ? **EST AGE:** 7-9 W / M / YR **BY:** Miller

TL: 137.5 CM **TAIL:** 30. CM **WT:** 36.4 KG **NOSE WOUND:** SIZE: S FRESHNESS: W

TEETH: 5=ALL MILK 6=SOME MILK 1=EXC 2=GOOD 3=FAIR 4=POOR 9=? REMARKS:

ECHINO: 0=NONE 1=SLIGHT 2=OBVIOUS 9=? (SKULL OR PCS EXAMINED, SEE BACK) REMARKS: not all teeth

GRIZZLE: 6=NATAL 7=JUV BUFF 1=NONE TO SLIGHT 2=TO EYES 3=TO LAMBDOIDAL CREST 4=TO CHEST 5=TO TAIL 9=?

RED ALGAE ON FUR: N / Y / ? VISUAL / UV LAMP 1=< 2% 2=2-10% 3=11-20% 4=>20% REMARKS:

NECROPSY: NO / F / G / D BY WHOM: B / BP / V / VP / P Miller, Young, Greenwald, Dodd, TMMC Fontaine, Halaska DATE: 8 Feb 2017

COND AT NEC: 2 / 3 / 4 / 5 **PREV FROZEN:** N / Y **LOCATION OF NECROPSY:** Dui MWVCRC

SUBCU FAT: 0=NONE 1=SCANT 2=FAIR 3=MOD 4=ABUND 9=? **TARRY DIGESTA:** 0=NOT OBVIOUS 1=SLIGHT 2=OBVIOUS 9=?

FOOD IN GUT: 0=EMPTY 1=LITTLE 2=MED 3=FULL 9=? PREY: Crab

ACANTH: UNK / NO / C / P / C=P / CP / PC INT: 0=NONE 1=MILD 2=MOD 3=HEAVY 9=? AB: 0=NONE 1=MILD 2=MOD 3=HEAVY 9=?

FETUS: N=NO Y=YES, NO SEX M=YES, MALE F=YES, FEMALE U=? TL: — CM CR: — CM WT: — GM

WOUNDS CHARC OF SHARK BITE: N / Y / ? **EFFORT TO CONFIRM:** 0=NONE 1=CURSORY 2=INTENSIVE 3=NA

WOUND DESCR: 1= NO OBVIOUS HEALING 2= INDICATION OF HEALING 3= INDICATION OF INFECTION 4= OBVIOUSLY OLD, HEALED 5= ? 6=NA

EVIDENCE WOUNDS ANTE-MORTEM: Y / ? / NA IF YES: SQ HEM yes OTHER: *: SQ hemorrhage and blood clots in mouth, nasopharynx, calvarium

REMARKS:
Otter found on railroad tracks between Yampah and Avila. Only visible injury is to the mouth/jaw which appears to be broken. Right flipper tag was cut off by the PC but given to Ron Eby. Ron Eby was contacted by the PC to retrieve the carcass. Radio frequency of this otter is: 166.484. Ron Eby (831)-383-8784

No gastric ulcers

PREMOLAR: N / UR UL LR LL **FUR:** N / Y **WHISKERS:** N / Y **OTHER SAMPLES:** N / Y (Y=SEE BACK) **PHOTOS:** N / Y

CAUSE OF STRANDING: 10 (TRAIN Hit By) **IF CODE=10 OR 11, THEN PRIMARY:** Train Strike

OTHER SIGNIFICANT FINDINGS: Nasal acariasis

DISPOSITION: CARCASS: ~~192~~ 192* ~~Ø~~ saved ~~until~~ PELT: Ø SKELETON: Ø SKULL: 192 BACULUM: 192 UNK PREMOLAR: Ø

FACTSHEET2016_V1 **CONTINUE ON BACK:** N / Y

SO# 8289-17

TAG REF #: BRD 1312-13 **KNOWN AGE:** N / Y **IF YES:** KA<3 MO KA<6 MO KA< 12MO

TAGS: R: YE / 4/5 / ____ MISSING? Y / N (COL POS NO.) **L:** ____ / 4/5 / ____ MISSING? Y / N (COL POS NO.) **PIT:** 4800 657A22 WORKING: Y / N / ?
not BMDS

TAG HX:
Captured 9/19/2013 @ Yampah W. VHF 166.486, no TDR, estimated @ 6yrs
wt 26.3 Kg, TL 134.2cm,

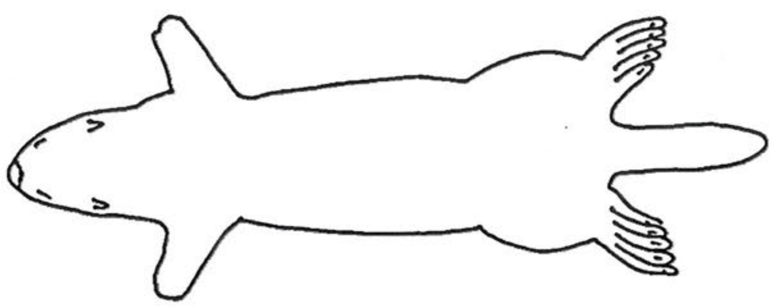
ECHINO: SKULL: 0=NONE 1=SLIGHT 2=OBVIOUS 9=? **PCS:** 0=NONE 1=SLIGHT 2=OBVIOUS 9=? REMARKS:

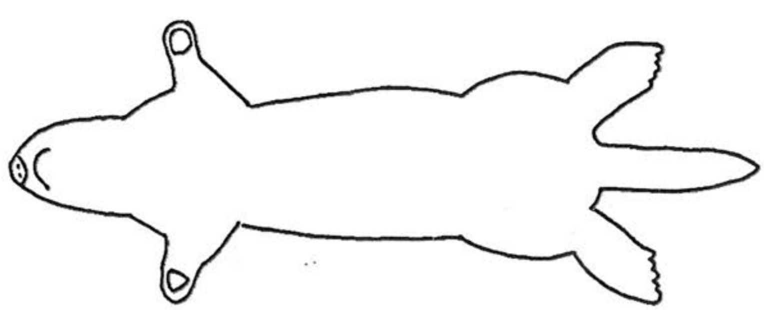
SAMPLES TAKEN: BI=BILE BL=BLOOD BR=BRAIN GC=GUT CONTENT HE=HEART KI=KIDNEY LI=LIVER LN=LYMPH NODE LU=LUNG MU=MUSCLE SP=SPLEEN UR = URINE ALL OTHER: testicle, thyroid, tongue, fat, PCF
FOR WHAT: WHOM:

HISTO SAMPLE: FULL / PARTIAL

XRAY: 1=YES,GUNSHOT 2=YES,NOT GUNSHOT 3=YES,GUNSHOT:OLD HEALED WOUND

ADDITIONAL REMARKS:
frozen: fat, PCF, Skull, ~~liver~~, ~~kidney~~,
histo: testicle, lung, heart, liver, kidney, tongue, skeletal muscle, brain, intercostal, thyroid, retropharyngeal LN





STRANDED SEA OTTER FACT SHEET

SO# 8322-17

PERSON REQUESTING SO#: K. Mayer

DATE FOUND: 01 (DD) Mar (MMM) 2017 (YYYY)

MWVCRC# 17-0045, 1750139

FOUND BY: PC RPC BO PM SBS SOB BIO UU — Sandbar Grill staff

OTHER# MBA 766-17, N-1640-16-S

RECOVERY AREA: 14 **ATOS:** 377B **LAT / LONG (DD): N** ____ **W** ____ **TC / GE**

RECOVERY LOCATION: Monterey Harbor, Sandbar Grill (CITY / COUNTY; LOCATION DETAILS, LANDMARKS) **TAR ON BEACH:** N / Y / ?

COND: 1=ALIVE (EUTH: Y / N) 2= FRESH 3=MOD DECOMP 4=ADV DECOMP 5=MUMM/FRAG/SKEL 9=? **SCAVENGED:** 0=NO 1= SLIGHT 2=MOD 3=HEAVILY 9=?

SEX: F / M / ? **AGE:** 2=PUP 3=IM 4 or 14 =SA 5 or 15 =AD 6=AGED AD 7=PUP OR IM 8=SA, AD, AA 9=? 3-3.5 mm

TAGGED: N / Y / ? (Y=PG 2) **TAR ON OTTER:** N / Y / ? **OBV TRAUMA:** N / Y / ? **EST AGE:** 3.0 W / M / YR **BY:** Staedler

TL: 113.9 CM 112@CDFW **TAIL:** 28 CM **WT:** 11.6 KG 11.5@CDFW **NOSE WOUND: SIZE:** S **FRESHNESS:** W

TEETH: 5=ALL MILK 6=SOME MILK 1=EXC 2=GOOD 3=FAIR 4=POOR 9=? REMARKS:

ECHINO: 0=NONE 1=SLIGHT 2=OBVIOUS 9=? (SKULL OR PCS EXAMINED, SEE BACK) REMARKS:

GRIZZLE: 6=NATAL 7=JUV BUFF 1=NONE TO SLIGHT 2=TO EYES 3=TO LAMBDOIDAL CREST 4=TO CHEST 5=TO TAIL 9=?

RED ALGAE ON FUR: N / Y / ? VISUAL / UV LAMP 1=< 2% 2=2-10% 3=11-20% 4=>20% REMARKS: light green fluor on tail

NECROPSY: NO / F / G / D BY WHOM: B / BP / V / VP / P Miller, Batac, Dodd, Young, Greenwald, Lu, Lyon, Guzman, Hartwick DATE: 3 Mar 2017

COND AT NEC: 2 / 3 / 4 / 5 **PREV FROZEN:** N / Y **LOCATION OF NECROPSY:** MWVCRC

SUBCU FAT: 0=NONE 1=SCANT 2=FAIR 3=MOD 4=ABUND 9=? **TARRY DIGESTA:** 0=NOT OBVIOUS 1=SLIGHT 2=OBVIOUS 9=?

FOOD IN GUT: 0=EMPTY 1=LITTLE 2=MED 3=FULL 9=? PREY:

ACANTH: UNK / NO / C / P / C=P / CP / PC INT: 0=NONE 1=MILD 2=MOD 3=HEAVY 9=? AB: 0=NONE 1=MILD 2=MOD 3=HEAVY 9=?

FETUS: N=NO Y=YES, NO SEX M=YES, MALE F=YES, FEMALE U=? TL: ____ CM CR: ____ CM WT: ____ GM

WOUNDS CHARC OF SHARK BITE: N / Y / ? **EFFORT TO CONFIRM:** 0=NONE 1=CURSORY 2=INTENSIVE 3= NA

WOUND DESCR: 1= NO OBVIOUS HEALING 2= INDICATION OF HEALING 3= INDICATION OF INFECTION 4= OBVIOUSLY OLD, HEALED 5= ? 6=NA

EVIDENCE WOUNDS ANTE-MORTEM: Y / ? / NA IF YES: SQ HEM OTHER:

REMARKS:
NSF study animal. Last observed 3 days ago without any notable anomalies except that she was not in her normal location (seen at Monterey Bay Inn, normally Otter Pt.). Today: observed in Monterey Harbor, very bloated with gas, difficulty lifting head out of water to breathe. Captured with dip net, brought to MBA for exam and radiographs. Marked accumulation of SQ gas over thorax and left abdomen (less over right abdomen), pocket of gas right cranial/ lateral abdomen, smaller amounts palpable over pelvic limbs.Tarry feces. Radiographs taken, blood collected. Decision to euthanize based on poor condition. Carcass will be sent to MWVCRC for necropsy.

PREMOLAR: N / UR UL LR LL **FUR:** N / Y **WHISKERS:** N / Y **OTHER SAMPLES:** N / Y (Y=SEE BACK) **PHOTOS:** N / Y

CAUSE OF STRANDING: 11p **IF CODE=10 OR 11, THEN PRIMARY:** SARCO

OTHER SIGNIFICANT FINDINGS: Gastric Ulcers, Emaciation

DISPOSITION: CARCASS: Ø PELT: ~~192~~ Ø SKELETON: Ø SKULL: 192 BACULUM: Ø PREMOLAR: 192

But sample for:
- Demodex study
- Thorak/Livwang study

echinochrome for CY

CONTINUE ON BACK: N / Y

FACTSHEET2016_V1

SO# 8322-17

TAG REF #: BRD 1364-16 **KNOWN AGE:** N / Y **IF YES:** KA<3 MO KA<6 MO KA< 12MO

TAGS: R: TQ / 1/2 / MBA 087 (COL / POS / NO.) MISSING? Y / N L: PU / 1/2 / MBA 085 (COL / POS / NO.) MISSING? Y / N **PIT:** 985141000930600 WORKING: Y / N / ?

TAG HX:

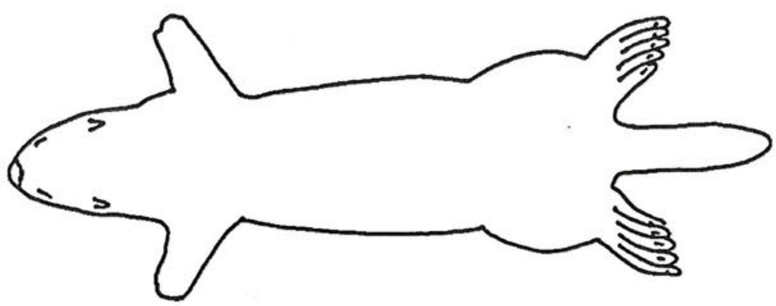
ECHINO: SKULL: 0=NONE 1=SLIGHT 2=OBVIOUS 9=? **PCS:** ~~0=NONE~~ 1=SLIGHT 2=OBVIOUS 9=? REMARKS:

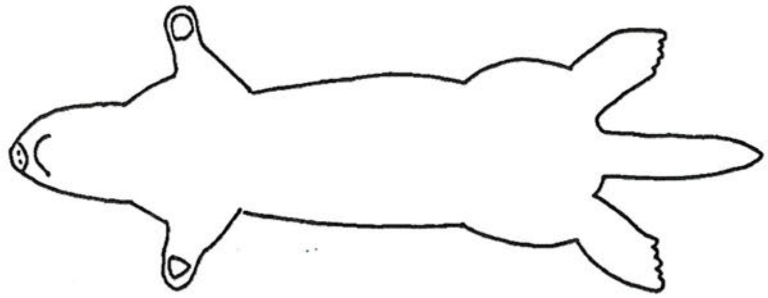
SAMPLES TAKEN: BI=BILE BL=BLOOD BR=BRAIN GC=GUT CONTENT HE=HEART KI=KIDNEY LI=LIVER LN=LYMPH NODE LU=LUNG MU=MUSCLE SP=SPLEEN UR = URINE ALL OTHER:
FOR WHAT: WHOM:

HISTO SAMPLE: FULL / PARTIAL

XRAY: 1=YES,GUNSHOT 2=YES,NOT GUNSHOT 3=YES,GUNSHOT:OLD HEALED WOUND

ADDITIONAL REMARKS:





(E) BRD1297-13

STRANDED SEA OTTER FACT SHEET

SO# 8381-17

PERSON REQUESTING SO#: K. Mayer

DATE FOUND: 04 (DD) Apr (MMM) 2017 (YYYY)

MWVCRC# 17-0067 175Ø220

FOUND BY: PC SBS KPC SOB BO BIO PM UU — MB Kayak shop guide

OTHER# N-1574-13-S (3-520)

RECOVERY AREA: 12 **ATOS:** 321B **LAT / LONG (DD):** N 36.811864 W -121.770552 **TC / GE**

RECOVERY LOCATION: Moss Landing/ Monterey Co; (CITY / COUNTY) SW side Seal Bend, Elkhorn Slough (LOCATION DETAILS, LANDMARKS) **TAR ON BEACH:** N / Y / ?

COND: 1=ALIVE 2=FRESH 3=MOD DECOMP 4=ADV DECOMP 5=MUMM/FRAG/SKEL 9=? **SCAVENGED:** 0=NO 1= SLIGHT 2=MOD 3=HEAVILY 9=?

EUTH: Y / N

SEX: F / M / ? **AGE:** 2=PUP 3=IM 4 or 14 =SA 5 or 15=AD 6=AGED AD 7=PUP OR IM 8=SA, AD, AA 9=?

TAGGED: N / Y / ? (Y=PG 2) **TAR ON OTTER:** N / Y / ? **OBV TRAUMA:** N / Y / ? **EST AGE:** 7-8 W / M / YR **BY:** FB

TL: 139 (checked twice) CM **TAIL:** 31 CM **WT:** 30.0 MBA KG **NOSE WOUND:** SIZE: S FRESHNESS: W

TEETH: 5=ALL MILK 6=SOME MILK 1=EXC 2=GOOD 3=FAIR 4=POOR 9=? REMARKS:

ECHINO: 0=NONE 1=SLIGHT 2=OBVIOUS 9=? (SKULL OR PCS EXAMINED, SEE BACK) REMARKS:

GRIZZLE: 6=NATAL 7=JUV BUFF 1=NONE TO SLIGHT 2=TO EYES 3=TO LAMBDOIDAL CREST 4=TO CHEST 5=TO TAIL 9=?

RED ALGAE ON FUR: N / Y / ? VISUAL / UV LAMP 1=< 2% 2=2-10% 3=11-20% 4=>20% REMARKS: Green algae on back

NECROPSY: NO / F / G / D BY WHOM: B / BP / V / VP / P FB, ANR, KG, CB DATE: 06 April 2017

COND AT NEC: 2 / 3 / 4 / 5 **PREV FROZEN:** N / Y **LOCATION OF NECROPSY:** MWVCRC

SUBCU FAT: 0=NONE 1=SCANT 2=FAIR 3=MOD 4=ABUND 9=? **TARRY DIGESTA:** 0=NOT OBVIOUS 1=SLIGHT 2=OBVIOUS 9=?

FOOD IN GUT: 0=EMPTY 1=LITTLE 2=MED 3=FULL 9=? PREY: Mud

ACANTH: UNK / NO / C / P / C=P / CP / PC INT: 0=NONE 1=MILD 2=MOD 3=HEAVY 9=? AB: 0=NONE 1=MILD 2=MOD 3=HEAVY 9=?

FETUS: N=NO Y=YES, NO SEX M=YES, MALE F=YES, FEMALE U=? TL: ____ CM CR: ____ CM WT: ____ GM

WOUNDS CHARC OF SHARK BITE: N / Y / ? **EFFORT TO CONFIRM:** 0=NONE 1=CURSORY 2=INTENSIVE 3= NA

WOUND DESCR: 1= NO OBVIOUS HEALING 2= INDICATION OF HEALING 3= INDICATION OF INFECTION 4= OBVIOUSLY OLD, HEALED 5= ? 6=NA

EVIDENCE WOUNDS ANTE-MORTEM: Y / ? / NA IF YES: SQ HEM OTHER:

REMARKS:
Elkhorn Slough study animal -- adult male (3-520) -- last resighted 31-Oct-2016. Carcass was recovered floating near shore at SW end of Seal Bend. There was blood coming from the head area, but didn't see obvious open wound or other obvious trauma, but also did not search thoroughly.

PREMOLAR: N / UR UL LR LL **FUR:** N / Y **WHISKERS:** N / Y **OTHER SAMPLES:** N / Y (Y=SEE BACK) **PHOTOS:** N / Y

CAUSE OF STRANDING: 11 P **IF CODE=10 OR 11, THEN PRIMARY:** Possible DA intoxication

OTHER SIGNIFICANT FINDINGS: Cardio Mod/Severe Nasal Mites, Infection

DISPOSITION: CARCASS: Ø PELT: Ø SKELETON: Ø SKULL: Ø BACULUM: Ø PREMOLAR: 192

FACTSHEET2016_v1

CONTINUE ON BACK: N / Y

Collection Date: 4/6/2017

SO# 8381-17 PAGE 2

NO CULTURES DONE, NO CULTURES DONE,

TAG REF #: BRD 1297-13 **KNOWN AGE:** N / Y **IF YES:** KA<3 MO KA<6 MO KA< 12MO

TAGS: R: HO / 4/5 / ____ (COL / POS / NO; MISSING? Y / N) L: HO / 1/2 / ____ (COL / POS / NO; MISSING? Y / N) **PIT:** 48016D5254 WORKING: Y / N / ?

TAG HX:
VHF Radio 173.520. Captured on 9/17/2013 in EHS @ Seal Bend, 28.7 Kg, 133.5 cm, est. Age 5 yrs, no TDR, VHF only

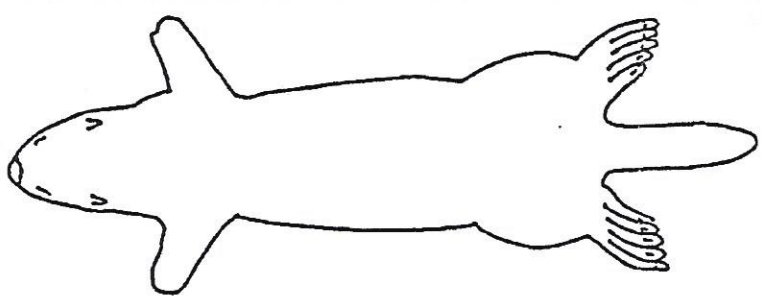
ECHINO: **SKULL:** 0=NONE 1=SLIGHT 2=OBVIOUS 9=? **PCS:** 0=NONE 1=SLIGHT 2=OBVIOUS 9=? REMARKS:

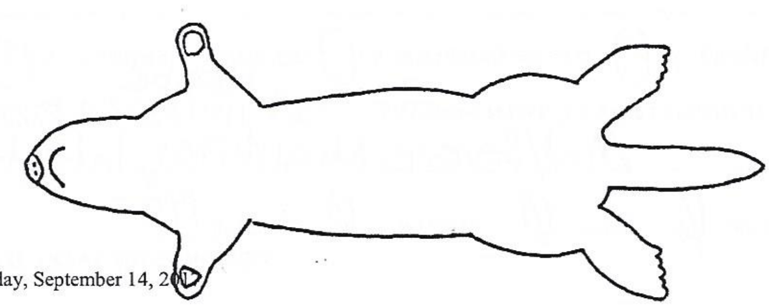
SAMPLES TAKEN: BI=BILE BL=BLOOD BR=BRAIN GC=GUT CONTENT HE=HEART KI=KIDNEY LI=LIVER LN=LYMPH NODE LU=LUNG MU=MUSCLE SP=SPLEEN UR = URINE ALL OTHER:
FOR WHAT: WHOM:

HISTO SAMPLE: FULL / PARTIAL

XRAY: 1=YES,GUNSHOT 2=YES,NOT GUNSHOT 3=YES,GUNSHOT:OLD HEALED WOUND

ADDITIONAL REMARKS:





STRANDED SEA OTTER FACT SHEET

SO# 8403-17

PERSON REQUESTING SO#: Ron Eby

DATE FOUND: 16 APR 2017 (DD MMM YYYY)

MWVCRC# 17-0089

FOUND BY: PC RPC BO PM SBS SOB BIO UU — Ron Eby

OTHER# BRD 1341-15

RECOVERY AREA: 12 **ATOS:** 321B **LAT / LONG (DD):** N 36.81157 W 121.78690 TC / GE

RECOVERY LOCATION: Elkhorn Slough, Montery (CITY / COUNTY) Packard Across From Kirby (LOCATION DETAILS, LANDMARKS) **TAR ON BEACH:** N / Y / ?

COND: 1=ALIVE (EUTH: Y / N) 2= FRESH 3=MOD DECOMP 4=ADV DECOMP 5=MUMM/FRAG/SKEL 9=? **SCAVENGED:** 0=NO 1= SLIGHT 2=MOD 3=HEAVILY ~~9=?~~

SEX: F / M / ? **AGE:** 2=PUP 3=IM 4 or 14 =SA 5 or 15 =AD 6=AGED AD 7=PUP OR IM 8=SA, AD, AA 9=?

TAGGED: N / Y / ? (Y=PG 2) ~~3-549~~ **TAR ON OTTER:** ~~N~~ / Y / ? **OBV TRAUMA:** ~~N~~ / Y / ? **EST AGE:** 8-9 W / M / YR **BY:** C Young

TL: — CM **TAIL:** — CM **WT:** — KG **NOSE WOUND:** SIZE: D FRESHNESS: D

TEETH: 5=ALL MILK 6=SOME MILK 1=EXC 2=GOOD 3=FAIR 4=POOR 9=? REMARKS:

ECHINO: 0=NONE 1=SLIGHT 2=OBVIOUS 9=? (SKULL OR PCS EXAMINED, SEE BACK) REMARKS:

GRIZZLE: 6=NATAL 7=JUV BUFF 1=NONE TO SLIGHT 2=TO EYES 3=TO LAMBDOIDAL CREST 4=TO CHEST 5=TO TAIL 9=?

RED ALGAE ON FUR: N / Y / ? VISUAL / UV LAMP 1=< 2% 2=2-10% 3=11-20% 4=>20% REMARKS:

NECROPSY: NO / F / G / D BY WHOM: B / BP / V / VP / P E Dodd, C Young DATE: 20 Apr 2017

COND AT NEC: 2 / 3 / 4 / 5 **PREV FROZEN:** N / Y **LOCATION OF NECROPSY:** MWVCRC

SUBCU FAT: 0=NONE 1=SCANT 2=FAIR 3=MOD 4=ABUND 9=? **TARRY DIGESTA:** 0=NOT OBVIOUS 1=SLIGHT 2=OBVIOUS 9=?

FOOD IN GUT: 0=EMPTY 1=LITTLE 2=MED 3=FULL 9=? PREY:

ACANTH: UNK / NO / C / P / C=P / CP / PC INT: 0=NONE 1=MILD 2=MOD 3=HEAVY 9=? AB: 0=NONE 1=MILD 2=MOD 3=HEAVY 9=?

FETUS: N=NO Y=YES, NO SEX M=YES, MALE F=YES, FEMALE U=? TL: ____ CM CR: ____ CM WT: ____ GM

WOUNDS CHARC OF SHARK BITE: N / Y / ? **EFFORT TO CONFIRM:** 0=NONE 1=CURSORY 2=INTENSIVE 3= NA

WOUND DESCR: 1= NO OBVIOUS HEALING 2= INDICATION OF HEALING 3= INDICATION OF INFECTION 4= OBVIOUSLY OLD, HEALED 5= ? 6=NA

EVIDENCE WOUNDS ANTE-MORTEM: Y / ? / NA IF YES: SQ HEM OTHER:

REMARKS:

Totally scavenged/mummified

No VHF

Originally captured 4/13/15 as adult (est. age 7) in Elkhorn Slough

Right (white) tag missing

Left (pink MBA 186) chewed up but present

Did not check pit tag

PREMOLAR: N / UR UL LR LL **FUR:** N / Y **WHISKERS:** N / Y **OTHER SAMPLES:** N / Y (Y=SEE BACK) **PHOTOS:** N / Y

CAUSE OF STRANDING: 1 **IF CODE=10 OR 11, THEN PRIMARY:**

OTHER SIGNIFICANT FINDINGS:

DISPOSITION: CARCASS: Ø PELT: Ø SKELETON: Ø SKULL: Ø BACULUM: Ø PREMOLAR: Ø

FACTSHEET2016_V1

CONTINUE ON BACK: N / Y

JCY

STRANDED SEA OTTER FACT SHEET

SO# 8443-17

PERSON REQUESTING SO#: K. Mayer

DATE FOUND: 12 (DD) May (MMM) 2017 (YYYY)

MWVCRC# 17-0128/ 1784353

FOUND BY: PC SBS RPC SOB BO BIO PM UU — K. Mayer

OTHER# MBA 784-17; UON N-1604-14-S; BRD 1328-14

RECOVERY AREA: 12 **ATOS:** 321B **LAT / LONG (DD): N** — **W** — **TC / GE**

RECOVERY LOCATION: Moss Landing, north harbor (CITY / COUNTY) Across from Sea Harvest (LOCATION DETAILS, LANDMARKS) **TAR ON BEACH:** N / Y / ?

COND: 1=ALIVE (EUTH/ Y, N) 2= FRESH 3=MOD DECOMP 4=ADV DECOMP 5=MUMM/FRAG/SKEL 9=? **SCAVENGED:** 0=NO 1= SLIGHT 2=MOD 3=HEAVILY 9=?

SEX: F / M / ? **AGE:** 2=PUP 3=IM 4 or 14 =SA 5 or 15 =AD 6=AGED AD 7=PUP OR IM 8=SA, AD, AA 9=?

TAGGED: N / Y / ? (Y=PG 2) **TAR ON OTTER:** N / Y / ? **OBV TRAUMA:** N / Y / ? **EST AGE:** 10-11 yr mm 14 W / M / YR **BY:** Staedler

TL: 137.6 CM 133 **TAIL:** 31.9 CM 31 **WT:** 28.5 KG ~30.0 wet **NOSE WOUND: SIZE:** S M **FRESHNESS:** P / W / P

TEETH: 5=ALL MILK 6=SOME MILK 1=EXC 2=GOOD 3=FAIR 4=POOR 9=? **REMARKS:** Premolars and molars worn, L U K9 fractured

ECHINO: 0=NONE 1=SLIGHT 2=OBVIOUS 9=? (SKULL OR PCS EXAMINED, SEE BACK) **REMARKS:**

GRIZZLE: 6=NATAL 7=JUV BUFF 1=NONE TO SLIGHT 2=TO EYES 3=TO LAMBDOIDAL CREST 4=TO CHEST 5=TO TAIL 9=?

RED ALGAE ON FUR: N / Y / ? VISUAL / UV LAMP 1=< 2% 2=2-10% 3=11-20% 4=>20% **REMARKS:**

NECROPSY: NO / F / G / D **BY WHOM:** B / BP / V / VP / P M Miller, E Dodd C Young L. Jaramillo-Ortiz (Tmmc International Vet) **DATE:** 15 May 2017

COND AT NEC: 2 / 3 / 4 / 5 **PREV FROZEN:** N / Y **LOCATION OF NECROPSY:** MWVCRC

SUBCU FAT: 0=NONE 1=SCANT 2=FAIR 3=MOD 4=ABUND 9=? **TARRY DIGESTA:** 0=NOT OBVIOUS 1=SLIGHT 2=OBVIOUS 9=?

FOOD IN GUT: 0=EMPTY 1=LITTLE 2=MED 3=FULL 9=? **PREY:** none

ACANTH: UNK / NO / C / P / C=P / CP / PC **INT:** 0=NONE 1=MILD 2=MOD 3=HEAVY 9=? **AB:** 0=NONE 1=MILD 2=MOD 3=HEAVY 9=?

FETUS: N=NO Y=YES, NO SEX M=YES, MALE F=YES, FEMALE U=? **TL:** — CM **CR:** — CM **WT:** — GM

WOUNDS CHARC OF SHARK BITE: N / Y / ? **EFFORT TO CONFIRM:** 0=NONE 1=CURSORY 2=INTENSIVE 3= NA

WOUND DESCR: 1= NO OBVIOUS HEALING 2= INDICATION OF HEALING 3= INDICATION OF INFECTION 4= OBVIOUSLY OLD, HEALED 5= ? 6=NA EST ~4-5d POST-BITE

EVIDENCE WOUNDS ANTE-MORTEM: Y / ? / NA **IF YES:** SQ HEM **OTHER:** infection, alive

REMARKS:
Referred to as "Bigfoot". Otter first seen in ML Harbor with apparent shark bite wounds on Wed 5/10/17. Wounds were oozing fluid and didn't seem fresh, but elected not to pick him up at that time. Hauled out again Friday morning (5/12/17). Found him in course of checking on another otter. Decision was to capture per discussion with MS, MM and AJ in order to evaluate at MBA. At MBA: has 2 bite wounds in dorsal thoracic region with abscess beginning to form, likely has broken ribs associated with wounds, and bites may penetrate thoracic cavity, 3rd bite wound in dorsal hip area seems more superficial. Based on age (14yrs estimated), poor prognosis for full recovery from injuries and sex, decision was to euthanize. Blood collected antemortem. Carcass will be transported to MWVCRC for necropsy.

Minor fight wounds

est 4-5 days interval btwn shark bite and euth
shark tooth frag found near vertebrae

OVER→

PREMOLAR: N / UR UL LR LL **FUR:** N / Y **WHISKERS:** N / Y **OTHER SAMPLES:** N / Y (Y=SEE BACK) **PHOTOS:** N / Y

CAUSE OF STRANDING: 4 **IF CODE=10 OR 11, THEN PRIMARY:** Sepsis

OTHER SIGNIFICANT FINDINGS: Sequelae: Sepsis; Contributing #1: Cardiomyopathy Contributing #2: Fight Trauma

DISPOSITION: CARCASS: ∅ **PELT:** ∅ **SKELETON:** ∅ **SKULL:** ∅ **BACULUM:** ∅ **PREMOLAR:** ~~∅~~ 192

FACTSHEET2016_V1

CONTINUE ON BACK: N / Y

SO# 8443-17

TAG REF #: BRD 1328-14 **KNOWN AGE:** N / Y **IF YES:** KA<3 MO KA<6 MO KA< 12MO

TAGS: R: YE / 4/5 / 6987 (COL / POS / NO.; MISSING? Y / N) **L:** RB / 1/2 / 6300 (COL / POS / NO.; MISSING? Y / N) **PIT:** None found **WORKING:** Y / N / ?

TAG HX:
Captured at Monterey Bay Inn, 23-Sep-2014. VHF radio 165.068. Age estimated at 11 years at time of capture.

ECHINO: SKULL: 0=NONE 1=SLIGHT 2=OBVIOUS 9=? **PCS:** 0=NONE 1=SLIGHT 2=OBVIOUS 9=? REMARKS:

SAMPLES TAKEN: BI=BILE BL=BLOOD BR=BRAIN GC=GUT CONTENT HE=HEART KI=KIDNEY LI=LIVER LN=LYMPH NODE LU=LUNG MU=MUSCLE SP=SPLEEN UR = URINE ALL OTHER:
FOR WHAT: WHOM:

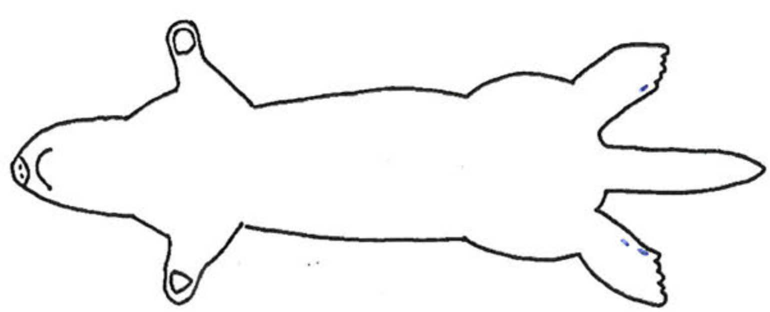
HISTO SAMPLE: FULL / PARTIAL

XRAY: 1=YES,GUNSHOT 2=YES,NOT GUNSHOT 3=YES,GUNSHOT:OLD HEALED WOUND NO

ADDITIONAL REMARKS:

No evidence of infection in:
- brain
- pleural cavity
- abdominal cavity

Severe infection SQ w/ PUS + MARKED SQ PETECHIATION



STRANDED SEA OTTER FACT SHEET

SO# 8447-17

PERSON REQUESTING SO#: J. Fujii

DATE FOUND: 15 (DD) May (MMM) 2017 (YYYY)

MWVCRC# 17-0129

FOUND BY: PC RPC BO PM SBS SOB BIO UU J. Fujii

OTHER# BRD # 1354-16

RECOVERY AREA: 14 **ATOS:** 381 **LAT / LONG (DD): N** **W** **TC / GE**

RECOVERY LOCATION: Hopkins Marine Station, Pacific Grove (CITY / COUNTY) (LOCATION DETAILS, LANDMARKS) **TAR ON BEACH:** N / Y / ?

COND: 1=ALIVE (EUTH: Y / N) 2=FRESH 3=MOD DECOMP 4=ADV DECOMP 5=MUMM/FRAG/SKEL 9=? **SCAVENGED:** 0=NO 1= SLIGHT 2=MOD 3=HEAVILY 9=?

SEX: F M / ? **AGE:** 2=PUP 3=IM 4 or ~~14=SA~~ 5 or 15=AD AA 6=AGED AD 7=PUP OR IM 8=SA, AD, AA 9=?

TAGGED: N / Y / ? (Y=PG 2) **TAR ON OTTER:** N Y / ? **OBV TRAUMA:** N Y / ? **EST AGE:** 4 W / M / YR **BY:** C Young

TL: 118 CM **TAIL:** 28 CM **WT:** 15.8 *wet KG **NOSE WOUND:** SIZE: M **FRESHNESS:** D (probably P/W)

TEETH: 5=ALL MILK 6=SOME MILK 1=EXC 2=GOOD 3=FAIR 4=POOR 9=? REMARKS:

ECHINO: 0=NONE 1=SLIGHT 2=OBVIOUS 9=? (SKULL OR PCS EXAMINED, SEE BACK) REMARKS:

GRIZZLE: 6=NATAL 7=JUV BUFF 1=NONE TO SLIGHT 2=TO EYES 3=TO LAMBDOIDAL CREST 4=TO CHEST 5=TO TAIL 9=?

RED ALGAE ON FUR: N Y / ? ~~VISUAL~~ / UV LAMP 1=< 2% 2=2-10% 3=11-20% 4=>20% REMARKS:

NECROPSY: NO / F / G / D BY WHOM: B / BP / V / VP / P M. Miller, E. Dodd, C. Young, K. Greenwald DATE: 16 May 2017

COND AT NEC: 2 / 3 / 4 / 5 **PREV FROZEN:** N Y **LOCATION OF NECROPSY:** MWVCRC

SUBCU FAT: 0=NONE 1=SCANT 2=FAIR 3=MOD 4=ABUND 9=? **TARRY DIGESTA:** 0=NOT OBVIOUS 1=SLIGHT 2=OBVIOUS 9=?

FOOD IN GUT: 0=EMPTY 1=LITTLE 2=MED 3=FULL 9=? PREY: none

ACANTH: UNK / NO / C / P / C=P / CP / PC INT: 0=NONE 1=MILD 2=MOD 3=HEAVY 9=? AB: 0=NONE 1=MILD 2=MOD 3=HEAVY 9=?

FETUS: N=NO Y=YES, NO SEX M=YES, MALE F=YES, FEMALE U=? TL: — CM CR: — CM WT: — GM

WOUNDS CHARC OF SHARK BITE: N Y / ? **EFFORT TO CONFIRM:** 0=NONE 1=CURSORY 2=INTENSIVE 3= NA

WOUND DESCR: 1= NO OBVIOUS HEALING 2= INDICATION OF HEALING 3= INDICATION OF INFECTION 4= OBVIOUSLY OLD, HEALED 5= ? 6=NA

EVIDENCE WOUNDS ANTE-MORTEM: Y / ? / NA IF YES: SQ HEM OTHER:

REMARKS:
From M. Staedler: She was captured at Otter Point and could regularly be found there until the kelp disappeared and we started seeing her around Lover's, Hopkins, and MBA with an occasional trip to the Great Tidepool past Point Pinos. Her diet consisted of mainly smaller crabs, followed by mussels, kelp crabs and urchins. She has not had any pups that we are aware of and lost her tags fairly early on, within two months after tagging. Radio resight on 5/11/2017 (signal sounded normal), last visually seen 5/10/2017 at Hopkins. Found dead 5/15/2017 (mortality signal/VHF).

- hyphema (L>R) ~~mild~~ - suture visibly closed but prominent by feel
- vulva mildly swollen
- red-tinged fluid coming from nose and mouth
- bite wounds on nose and upper lip (subacute → chronic)
- SQ air ~~in~~ chest and abdomen (PM autolysis) OVER →

PREMOLAR: N / UR UL LR LL **FUR:** N / Y **WHISKERS:** N / Y **OTHER SAMPLES:** N / Y (Y=SEE BACK) **PHOTOS:** N / Y

(No tooth collected at capture)

CAUSE OF STRANDING: 3P **IF CODE=10 OR 11, THEN PRIMARY:**

OTHER SIGNIFICANT FINDINGS:

DISPOSITION: CARCASS: Ø PELT: Ø SKELETON: Ø SKULL: ~~Ø~~ 192 ↳ echino study BACULUM: Ø PREMOLAR: 192

CONTINUE ON BACK: N / Y

FACTSHEET2016_V1

SO# 8447-17

TAG REF #: BRD 1354-16 **KNOWN AGE:** N Y **IF YES:** KA<3 MO KA<6 MO KA< 12MO

TAGS: R: TQ / 1/2 / MBA 295 (COL / POS / NO.; MISSING ✓ Y N) **L:** PU / 4/5 / MBA 102 (COL / POS / NO.; MISSING ✓ Y N) **PIT:** 985141000929910 **WORKING** Y / N / ?

TAG HX:
BRD 1354-16 was captured on 6/2/2016 for the NSF study. Also known as "Three" because of her radio frequency 166.333. She was also given a TDR, serial number 1690124. She was considered a sub adult female with a birth date of 2/1/14. She weighed 15.40 kg at time of implant.

ECHINO: SKULL: 0=NONE 1=SLIGHT 2=OBVIOUS 9=? **PCS:** 0=NONE 1=SLIGHT 2=OBVIOUS 9=? REMARKS:

SAMPLES TAKEN: BI=BILE BL=BLOOD BR=BRAIN GC=GUT CONTENT HE=HEART KI=KIDNEY LI=LIVER LN=LYMPH NODE LU=LUNG
MU=MUSCLE SP=SPLEEN UR = URINE ALL OTHER:
FOR WHAT: WHOM:

HISTO SAMPLE: FULL / PARTIAL

XRAY: 1=YES,GUNSHOT 2=YES,NOT GUNSHOT 3=YES,GUNSHOT:OLD HEALED WOUND NO

ovaries - small, smooth
Ø ploc scars
mod P/W nose wound;
lungs collapsed; scant red fluid in chest + abd.

ADDITIONAL REMARKS:

Cause of death not evident from gross exam. Hopefully histo will be more informative

(mod decomp.)

Bact inject: omentum diff congested, opaque
SI serosa red but mucosa WNL;
Ø twists, Ø adhesions
SI bunched but no adhesions or twists

Hyphema OU (L > R)

Diffuse congestion + patchy SQ red-tinged edema (DDx autolysis)

as per DSOFS + 10-page report

~~Fair~~ Scant SQ adipose + mild skel. mm atrophy

TDR in falciform - VHF free floating - Similar edema/red discoloration in pocket around TDR + caudal aspect of V. midline incision - Sutures, prominent + partially resorbed ~~bag~~ but Ø adhesions

Variable mild-marked lymphad. + congestion

STRANDED SEA OTTER FACT SHEET

SO# 8455-17

PERSON REQUESTING SO#: C YOUNG

DATE FOUND: 22 (DD) MAY (MMM) 2017 (YYYY)

MWVCRC# 17-01164

FOUND BY: PC RPC BO PM SBS SOB BIO UU Ron Eby

OTHER# BRD 1337 1750384

RECOVERY AREA: 12 **ATOS:** 321B **LAT / LONG (DD): N** 36.81049 **W** -121.78592 TC / GE

RECOVERY LOCATION: Elkhorn Slough, Yampah area, Monterey County (CITY / COUNTY; LOCATION DETAILS, LANDMARKS) **TAR ON BEACH:** N / Y / ?

COND: 1=ALIVE (EUTH: Y / N) 2=FRESH 3=MOD DECOMP 4=ADV DECOMP 5=MUMM/FRAG/SKEL 9=? **SCAVENGED:** 0=NO 1=SLIGHT 2=MOD 3=HEAVILY 9=?

SEX: F / M / ? **AGE:** 2=PUP 3=IM 4 or 14 =SA 5 or 15=AD 6=AGED AD 7=PUP OR IM 8=SA, AD, AA 9=?

TAGGED: N / Y / ? (Y=PG 2) **TAR ON OTTER:** N / Y / ? **OBV TRAUMA:** N / Y / ? **EST AGE:** ~7 W / M / YR **BY:** MM

TL: 121 CM **TAIL:** 26 CM **WT:** 17.7 KG **NOSE WOUND:** SIZE: D FRESHNESS: D

TEETH: 5=ALL MILK 6=SOME MILK 1=EXC 2=GOOD 3=FAIR 4=POOR 9=? REMARKS:

ECHINO: 0=NONE 1=SLIGHT 2=OBVIOUS 9=? (SKULL OR PCS EXAMINED, SEE BACK) REMARKS: upper incisors

GRIZZLE: 6=NATAL 7=JUV BUFF 1=NONE TO SLIGHT 2=TO EYES 3=TO LAMBDOIDAL CREST 4=TO CHEST 5=TO TAIL 9=? [illegible]

RED ALGAE ON FUR: N / Y / ? VISUAL / UV LAMP 1=< 2% 2=2-10% 3=11-20% 4=>20% REMARKS:

NECROPSY: NO / F / G / D BY WHOM: B / BP / V / VP / P Miller, Dodd, Greenwald DATE: 24 May 2017

COND AT NEC: 2 / 3 / 4 / 5 **PREV FROZEN:** N / Y **LOCATION OF NECROPSY:** MWVCRC

SUBCU FAT: 0=NONE 1=SCANT ~~2=FAIR~~ 3=MOD 4=ABUND 9=? **TARRY DIGESTA:** 0=NOT OBVIOUS 1=SLIGHT 2=OBVIOUS 9=?

FOOD IN GUT: 0=EMPTY 1=LITTLE 2=MED 3=FULL 9=? PREY: clam, crab,

ACANTH: UNK / NO / C / P / C=P / CP / PC INT: 0=NONE 1=MILD 2=MOD 3=HEAVY 9=? AB: 0=NONE 1=MILD 2=MOD 3=HEAVY 9=?

FETUS: N=NO Y=YES, NO SEX M=YES, MALE F=YES, FEMALE U=? TL: ___ CM CR: ___ CM WT: ___ GM

WOUNDS CHARC OF SHARK BITE: N / Y / ? **EFFORT TO CONFIRM:** 0=NONE 1=CURSORY 2=INTENSIVE 3=NA

WOUND DESCR: 1= NO OBVIOUS HEALING 2= INDICATION OF HEALING 3= INDICATION OF INFECTION 4= OBVIOUSLY OLD, HEALED 5= ? 6=NA

EVIDENCE WOUNDS ANTE-MORTEM: Y / ? / NA IF YES: SQ HEM OTHER:

REMARKS:
From Ron Eby: Carcass was high marsh. There was lots of scat in the area. Dead pup found about 2 meters from this animal and didn't seem as decomposed. This animal last seen alive on 5/10/2017 with pup (est. ~1 month old - est. DOB 4/25/2017).

① POSSIBLE DA INTOX., CHAR BY: - ACUTE DEATH IN GOOD NUTRITIONAL CONDITION W/ STOMACH FULL OF PARTIALLY DIGESTED PREY
② STAGE 3 FEMALE, ABUNDANT MAMMARY TISSUE, CERVIX CLOSED, Ø LACTATING, VULVA UNK (PART. SCAVENGED), ØCLS, FOLLICLES OR CYSTS, ~3 CAS (2 L / 1 R) PLAC. SCAR L (MAMMARY TISSUE PINK ~1.2 CM THICK)

PREMOLAR: N / UR UL LR LL **FUR:** N / Y **WHISKERS:** N / Y **OTHER SAMPLES:** N / Y (Y=SEE BACK) **PHOTOS:** N / Y

CAUSE OF STRANDING: 11p **IF CODE=10 OR 11, THEN PRIMARY:** POSS DA INTOX

OTHER SIGNIFICANT FINDINGS:

DISPOSITION: CARCASS: 0 PELT: 0 SKELETON: 0 SKULL: 0 BACULUM: 0 PREMOLAR: 192

FACTSHEET2016_V1

CONTINUE ON BACK: N / Y

20.7
- 3.

③ POSSIBLE STREAKING OF VENTRICULAR MYOCARDIUM (ADX AUTOLYSIS)

SO# 8455-17

TAG REF #: BRD 1337 ← 15 **KNOWN AGE:** ✓N / Y **IF YES:** KA<3 MO KA<6 MO KA< 12MO

TAGS: **R:** CH / 1/2 / MBA115 (COL / POS / NO.; MISSING? Y / N ✓) **L:** WH / 1/2 / MBA109 (COL / POS / NO.; MISSING? Y / N ✓) **PIT:** ES2015008 **WORKING:** Y / N / ?

TAG HX: PEND: ① HP HEART
② DA: STOMACH + LG CONTENT (+ URINE FOR 8456-17) POSS PUP
③ MUSCLE OUT FOR DNA / PARENTAGE ON AF + 8456-17

ECHINO: SKULL: 0=NONE 1=SLIGHT 2=OBVIOUS 9=? **PCS:** 0=NONE 1=SLIGHT 2=OBVIOUS 9=? **REMARKS:** (Adult Female)

DA Stomach Histo RECTAL DIGESTA

SAMPLES TAKEN: BI=BILE BL=BLOOD BR=BRAIN GC=GUT CONTENT HE=HEART KI=KIDNEY LI=LIVER LN=LYMPH NODE LU=LUNG MU=MUSCLE SP=SPLEEN UR = URINE ALL OTHER: WHISKER

FOR WHAT: WHOM:

HISTO SAMPLE: FULL / PARTIAL heart

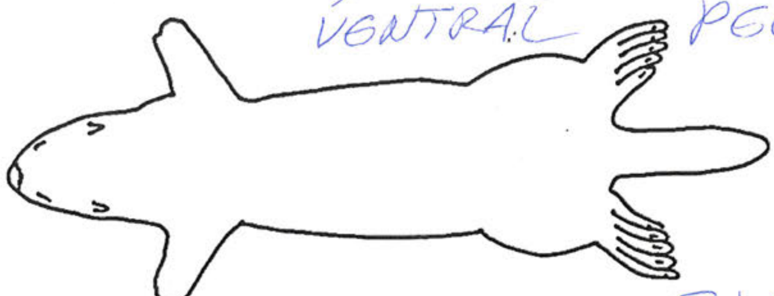
XRAY: 1=YES,GUNSHOT 2=YES,NOT GUNSHOT 3=YES,GUNSHOT:OLD HEALED WOUND NO

ADDITIONAL REMARKS:

④ MODERATE INTESTINAL MELENA (Ø GASTRIC EROSIONS OR ULCERS)

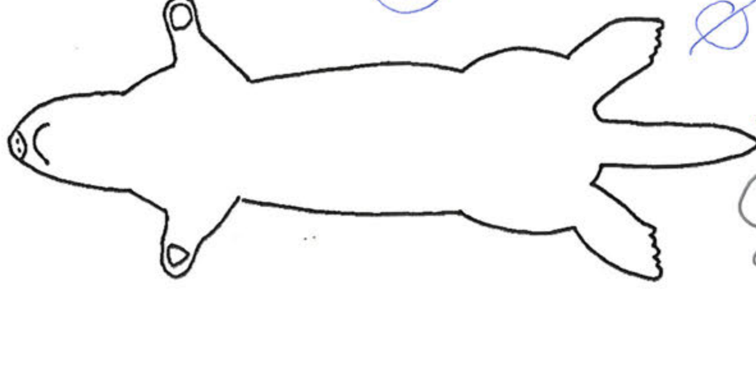
FOUND W/ POSSIBLE PUP (8456-17) ALSO DEAD NEARBY + SL LESS DECOMPOSED

⑤ MINIMALLY SCAVENGED THRU ANUS, SQ GAS, DESSICATION OF ~~DOP~~ VENTRAL PELAGE, ~1 cm MAGGOTS MOUTH, ANUS, FUR SLOUGHING



⑥ ~~SQ~~ SX INCISION WNL Ø ADHESIONS, VHF FREE-FLOATING RC ABD, Ø TDR

(right cranial)



BRD 1366-16

STRANDED SEA OTTER FACT SHEET

SO# 8646-17

PERSON REQUESTING SO#: C. Donegan

DATE FOUND: 01 (DD) Oct (MMM) 2017 (YYYY)

MWVCRC# 17-0529

FOUND BY: PC SBS RPC SOB BO BIO PM UU — Cynthia (BeachCOMBER)

OTHER# BRD 1366

RECOVERY AREA: 13 **ATOS:** 368 **LAT / LONG (DD): N** — **W** — **TC / GE**

RECOVERY LOCATION: Sand City/Monterey County Monterey State Beach, 100yrd S of Tioga (CITY / COUNTY; LOCATION DETAILS, LANDMARKS) **TAR ON BEACH:** N / Y / ?

COND: 1=ALIVE (EUTH: Y / N) 2=FRESH 3=MOD DECOMP 4=ADV DECOMP 5=MUMM/FRAG/SKEL 9=? **SCAVENGED:** 0=NO 1= SLIGHT 2=MOD 3=HEAVILY 9=?

SEX: F / M / ? **AGE:** 2=PUP 3=IM 4 or 14 =SA 5 or 15 =AD 6=AGED AD 7=PUP OR IM 8=SA, AD, AA 9=?

TAGGED: N / Y / ? (Y=PG 2) **TAR ON OTTER:** N / Y / ? **OBV TRAUMA:** N / Y / ? **EST AGE:** 8 W / M / YR **BY:** Young

TL: 116 CM **TAIL:** 27 CM **WT:** — KG **NOSE WOUND:** SIZE: D FRESHNESS: D

TEETH: 5=ALL MILK 6=SOME MILK 1=EXC 2=GOOD 3=FAIR 4=POOR 9=? REMARKS:

ECHINO: 0=NONE 1=SLIGHT 2=OBVIOUS 9=? (SKULL OR PCS EXAMINED, SEE BACK) REMARKS: Skull purple - see back

GRIZZLE: 6=NATAL 7=JUV BUFF 1=NONE TO SLIGHT 2=TO EYES 3=TO LAMBDOIDAL CREST 4=TO CHEST 5=TO TAIL 9=?

RED ALGAE ON FUR: N / Y / ? VISUAL / UV LAMP 1=< 2% 2=2-10% 3=11-20% 4=>20% REMARKS:

NECROPSY: NO F / G / D BY WHOM: B BP / V / VP / P C. Young, F. Batac, E. Dodd DATE: 02 Oct. 2017

COND AT NEC: 2 / 3 / 4 / 5 **PREV FROZEN:** N / Y **LOCATION OF NECROPSY:** MWVCRC

SUBCU FAT: 0=NONE 1=SCANT 2=FAIR 3=MOD 4=ABUND 9=? **TARRY DIGESTA:** 0=NOT OBVIOUS 1=SLIGHT 2=OBVIOUS 9=?

FOOD IN GUT: 0=EMPTY 1=LITTLE 2=MED 3=FULL 9=? PREY: scavenged

ACANTH: UNK / NO / C / P / C=P / CP / PC INT: 0=NONE 1=MILD 2=MOD 3=HEAVY 9=? AB: 0=NONE 1=MILD 2=MOD 3=HEAVY 9=?

FETUS: N=NO Y=YES, NO SEX M=YES, MALE F=YES, FEMALE U=? TL: — CM CR: — CM WT: — GM

WOUNDS CHARC OF SHARK BITE: N / Y / ? **EFFORT TO CONFIRM:** 0=NONE 1=CURSORY 2=INTENSIVE 3= NA

WOUND DESCR: 1= NO OBVIOUS HEALING 2= INDICATION OF HEALING 3= INDICATION OF INFECTION 4= OBVIOUSLY OLD, HEALED 5= ? 6=NA

EVIDENCE WOUNDS ANTE-MORTEM: Y / ? NA IF YES: SQ HEM OTHER:

REMARKS:

- Found 100 yards S. of Tioga Ave entrance to Monterey State Beach. Advanced decomposition. PC called phone number on VHF tracker that was outside of carcass, could not find ~~tag~~ VHF when otter was recovered.
- Surgical scar ~~NSF~~ unremarkable externally, not found internally
- 2 lg holes in pelt @ base of tail: likely scavenging through vagina/anus
- One small hole in pelt on L arm - source unknown
- most fur sloughed off
- all abdominal organs except kidneys scavenged
- chest cavity partially scavenged
- No TDR or VHF found in carcass.

OVER→

PREMOLAR: N / UR UL LR LL **FUR:** N / Y **WHISKERS:** N / Y (None available) **OTHER SAMPLES:** N / Y (Y=SEE BACK) **PHOTOS:** N / Y

CAUSE OF STRANDING: 1 **IF CODE=10 OR 11, THEN PRIMARY:**

OTHER SIGNIFICANT FINDINGS:

DISPOSITION: CARCASS: O PELT: O SKELETON: O SKULL: 192 BACULUM: O PREMOLAR: 192

↳echino (in CY holding bin)

CONTINUE ON BACK: N / Y

FACTSHEET2016_V1

JCY

SO# 8646-17

TAG REF #: BRD 1366 **KNOWN AGE:** N / Y **IF YES:** KA<3 MO KA<6 MO KA< 12MO

TAGS: R: TQ / Y2 / 354 (MISSING? Y / N) MBA L: YE / Y2 / 3046 (MISSING? Y / N) **PIT:** not found **WORKING:** Y / N / ?

COL POS NO. COL POS NO.

TAG HX: 6/6/2016 captured@Cypress parking, implanted w TDR 1690070 VHF 166.344, 985141000930611(PIT)

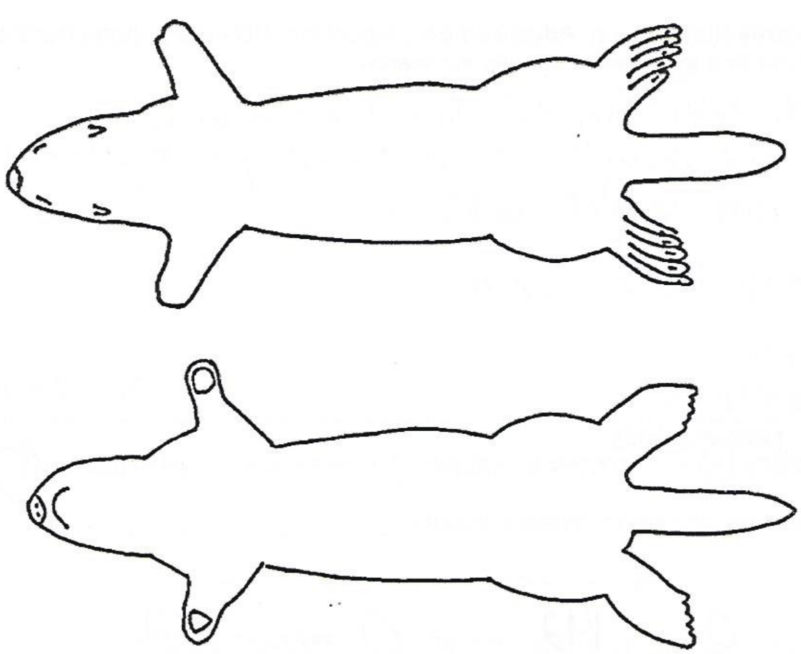
ECHINO: SKULL: 0=NONE 1=SLIGHT 2=OBVIOUS 9=? **PCS:** 0=NONE 1=SLIGHT 2=OBVIOUS 9=? REMARKS:

SAMPLES TAKEN: BI=BILE BL=BLOOD BR=BRAIN GC=GUT CONTENT HE=HEART KI=KIDNEY LI=LIVER LN=LYMPH NODE LU=LUNG MU=MUSCLE SP=SPLEEN UR = URINE ALL OTHER: NONE
FOR WHAT: WHOM:

HISTO SAMPLE: FULL / PARTIAL NONE

XRAY: 1=YES,GUNSHOT 2=YES,NOT GUNSHOT 3=YES,GUNSHOT:OLD HEALED WOUND No

ADDITIONAL REMARKS:
S. Lyon scanned for VHF frequency on 02 Oct but did not detect it.



STRANDED SEA OTTER FACT SHEET

SO# 8254-17

PERSON REQUESTING SO#: Jessica Fujii

DATE FOUND: 05 (DD) JAN (MMM) 2017 (YYYY)

MWVCRC# 17-0012

OTHER# 17S0015

FOUND BY: PC RPC BO PM SBS SOB BIO UU PC

RECOVERY AREA: 13 **ATOS:** 374 **LAT / LONG (DD): N** 36.602483 **W** -121.875328 TC / GE

RECOVERY LOCATION: Del Monte Beach (CITY / COUNTY), Monterey County (LOCATION DETAILS, LANDMARKS) **TAR ON BEACH:** N / Y / ?

COND: 1=ALIVE (EUTH: Y / N) 2=FRESH 3=MOD DECOMP 4=ADV DECOMP 5=MUMM/FRAG/SKEL 9=? **SCAVENGED:** 0=NO 1= SLIGHT 2=MOD 3=HEAVILY 9=?

SEX: F / M / ? **AGE:** 2=PUP 3=IM 4 or 14 =SA 5 or 15=AD 6=AGED AD 7=PUP OR IM 8=SA, AD, AA 9=?

TAGGED: N / Y / ? (Y=PG 2) **TAR ON OTTER:** N / Y / ? **OBV TRAUMA:** N / Y / ? **EST AGE:** ~~6~~ 8 W / M / YR **BY:** MM, CY

22.9

TL: 117.0 CM **TAIL:** 29 CM **WT:** 22.9 KG **NOSE WOUND:** SIZE: L FRESHNESS: R

TEETH: 5=ALL MILK 6=SOME MILK 1=EXC 2=GOOD 3=FAIR 4=POOR 9=? REMARKS:

ECHINO: 0=NONE 1=SLIGHT 2=OBVIOUS 9=? (SKULL OR PCS EXAMINED, SEE BACK) REMARKS:

GRIZZLE: 6=NATAL 7=JUV BUFF 1=NONE TO SLIGHT 2=TO EYES 3=TO LAMBDOIDAL CREST 4=TO CHEST 5=TO TAIL 9=?

RED ALGAE ON FUR: N / Y / ? VISUAL / UV LAMP 1=< 2% 2=2-10% 3=11-20% 4=>20% REMARKS:

NECROPSY: NO / F / G / D BY WHOM: B / BP / V / VP / P M. Miller, E. Dodd, K. Greenwald, C. Young DATE: 06 Jan 2017

COND AT NEC: 2 / 3 / 4 / 5 **PREV FROZEN:** N / Y **LOCATION OF NECROPSY:** MWVCRC

SUBCU FAT: 0=NONE 1=SCANT 2=FAIR 3=MOD 4=ABUND 9=? **TARRY DIGESTA:** 0=NOT OBVIOUS 1=SLIGHT 2=OBVIOUS 9=?

FOOD IN GUT: 0=EMPTY 1=LITTLE 2=MED 3=FULL 9=? PREY: sea star, crab, mussel

MINIMAL PROFILICOLLIS

ACANTH: UNK / NO / C / P / C=P / CP / PC INT: 0=NONE 1=MILD 2=MOD 3=HEAVY 9=? AB: 0=NONE 1=MILD 2=MOD 3=HEAVY 9=?

MILD CORYNOSOMA P

FETUS: N=NO Y=YES, NO SEX M=YES, MALE F=YES, FEMALE U=? TL: — CM CR: — CM WT: — GM

WOUNDS CHARC OF SHARK BITE: N / Y / ? **EFFORT TO CONFIRM:** 0=NONE 1=CURSORY 2=INTENSIVE 3=NA

WOUND DESCR: 1= NO OBVIOUS HEALING 2= INDICATION OF HEALING 3= INDICATION OF INFECTION 4= OBVIOUSLY OLD, HEALED 5= ? 6=NA

EVIDENCE WOUNDS ANTE-MORTEM: Y / ? / NA IF YES: SQ HEM OTHER:

REMARKS:
Captured in 2014. Resights between Otter Point and Monterey Bay Inn. Last resight was on 12/30/2016.

PREMOLAR: ~~X~~ / UR UL LR LL **FUR:** N / Y **WHISKERS:** N / Y **OTHER SAMPLES:** N / Y (Y=SEE BACK) **PHOTOS:** ~~N~~ / Y

CAUSE OF STRANDING: 11 **IF CODE=10 OR 11, THEN PRIMARY:** CARDIOMYOPATHY

OTHER SIGNIFICANT FINDINGS: HEPATIC THROMBUS

DISPOSITION: CARCASS: Ø PELT: 192 SKELETON: Ø SKULL: Ø BACULUM: Ø PREMOLAR: ~~Ø~~ 192

Saved for CDFW-OSPR SACTO

CONTINUE ON BACK: N / Y

FACTSHEET2016_V1

SO# 8254-17

TAG REF #: BRD 1336-14 **KNOWN AGE:** N / Y **IF YES:** KA<3 MO KA<6 MO KA< 12MO

TAGS: R: TQ / 1/2 / MBA 393 (COL / POS / NO.; MISSING? Y / N) **L:** SI / 4/5 / 5036 (COL / POS / NO.; MISSING? Y / N) **PIT:** 985111000243405 WORKING: Y / N / ?

TAG HX:

ECHINO: SKULL: 0=NONE 1=SLIGHT 2=OBVIOUS 9=? **PCS:** 0=NONE 1=SLIGHT 2=OBVIOUS 9=? REMARKS:

SAMPLES TAKEN: BI=BILE BL=BLOOD BR=BRAIN GC=GUT CONTENT HE=HEART KI=KIDNEY LI=LIVER LN=LYMPH NODE LU=LUNG MU=MUSCLE SP=SPLEEN UR = URINE ALL OTHER: ALL

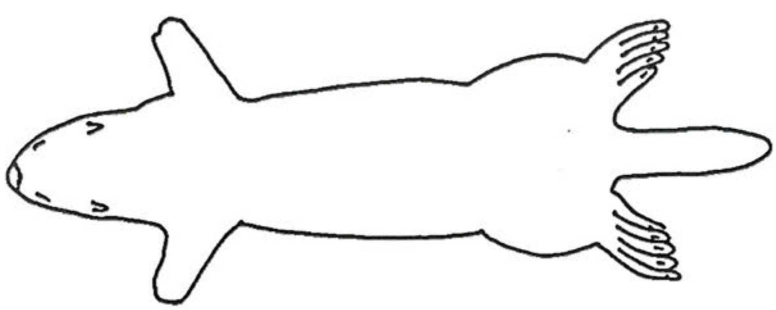
FOR WHAT: WHOM:

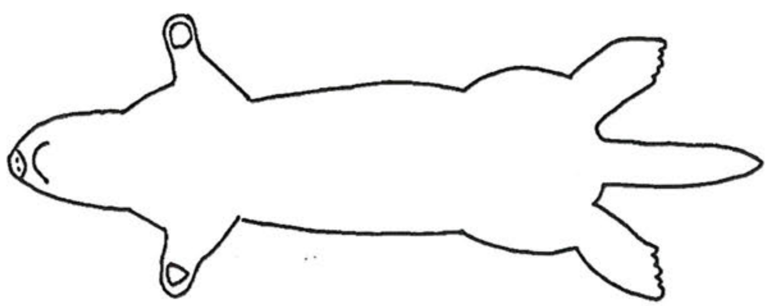
HISTO SAMPLE: FULL / PARTIAL

~~XRAY:~~ 1=YES,GUNSHOT 2=YES,NOT GUNSHOT 3=YES,GUNSHOT:OLD HEALED WOUND

ADDITIONAL REMARKS:

See gross report





(E) BRD 999-05-3

STRANDED SEA OTTER FACT SHEET

SO# 8385-17

PERSON REQUESTING SO#: Donegan/ Nicholson

DATE FOUND: 08 (DD) Apr (MMM) 2017 (YYYY)

MWVCRC# 17-0069 BRD 999

FOUND BY: SBS (PC) SOB (RPC) BIO (BO) UU (PM) PC --> MBA

OTHER# N-1274-05-S, MBA 777-17, 1750233

RECOVERY AREA: 15 **ATOS:** 386 **LAT / LONG (DD): N** — **W** — D1057 **TC / GE**

RECOVERY LOCATION: Pacific Grove/ Monterey (CITY / COUNTY) Lucas Pt. (LOCATION DETAILS, LANDMARKS) **TAR ON BEACH:** N / Y / ?

COND: 1=ALIVE (EUTH Y / N) 2= FRESH 3=MOD DECOMP 4=ADV DECOMP 5=MUMM/FRAG/SKEL 9=? **SCAVENGED:** 0=NO 1= SLIGHT 2=MOD 3=HEAVILY 9=?

SEX: F / M / ? **AGE:** 2=PUP 3=IM 4 or 14 =SA 5 or 15 =AD 6=AGED AD 7=PUP OR IM 8=SA, AD, AA 9=?

TAGGED: N / Y ? (Y=PG 2) **TAR ON OTTER:** N / Y / ? **OBV TRAUMA:** N / Y / ? **EST AGE:** 11-12 W / M / YR **BY:** F. Batac
14-15 yr based on est. age (SA) during 1st capture

TL: 117 CM **TAIL:** 29 CM **WT:** 12.3 KG 12.6 @ mwvcrc **NOSE WOUND:** SIZE: L FRESHNESS: P

TEETH: 5=ALL MILK 6=SOME MILK 1=EXC 2=GOOD 3=FAIR 4=POOR 9=? REMARKS: see clinical notes

ECHINO: 0=NONE 1=SLIGHT 2=OBVIOUS 9=? (SKULL OR PCS EXAMINED, SEE BACK) REMARKS:

GRIZZLE: 6=NATAL 7=JUV BUFF 1=NONE TO SLIGHT 2=TO EYES 3=TO LAMBDOIDAL CREST 4=TO CHEST 5=TO TAIL 9=?

RED ALGAE ON FUR: N / Y / ? VISUAL / UV LAMP 1=< 2% 2=2-10% 3=11-20% 4=>20% REMARKS:

NECROPSY: NO / F / G / D BY WHOM: B / BP / V / VP / P C. Young, K. Greenwald, F. Batac **DATE:** 10 Apr 2017

COND AT NEC: 2 / 3 / 4 / 5 **PREV FROZEN:** N / Y **LOCATION OF NECROPSY:** mwvcrc

SUBCU FAT: 0=NONE 1=SCANT 2=FAIR 3=MOD 4=ABUND 9=? **TARRY DIGESTA:** ~~0=NOT OBVIOUS~~ 1=SLIGHT 2=OBVIOUS 9=?

FOOD IN GUT: 0=EMPTY 1=LITTLE 2=MED 3=FULL 9=? PREY:

ACANTH: UNK / NO / C / P / C=P / CP / PC INT: 0=NONE 1=MILD 2=MOD 3=HEAVY 9=? AB: 0=NONE 1=MILD 2=MOD 3=HEAVY 9=?

FETUS: N=NO Y=YES, NO SEX M=YES, MALE F=YES, FEMALE U=? TL: 17 CM CR: 15.5 CM WT: 83.5 GM

WOUNDS CHARC OF SHARK BITE: N / Y / ? **EFFORT TO CONFIRM:** 0=NONE 1=CURSORY 2=INTENSIVE 3=NA

WOUND DESCR: 1= NO OBVIOUS HEALING 2= INDICATION OF HEALING 3= INDICATION OF INFECTION 4= OBVIOUSLY OLD, HEALED 5= ? 6=NA

EVIDENCE WOUNDS ANTE-MORTEM: Y / ? / NA IF YES: SQ HEM OTHER:

REMARKS:
Long term Monterey-area study animal originally tagged in 2005. Hauling out in intertidal rocks at Lucas Pt. beginning Friday (7-Apr). Observed mating several times prior to this. Obviously emaciated, minimally responsive to people approaching. Seemed to get progressively weaker over 24 hour period. Decision to pick her up was made after she hauled out following unsuccessful attempts to forage (per T. Nicholson).

PREMOLAR: N / UR UL LR LL **FUR:** N / Y **WHISKERS:** N / Y **OTHER SAMPLES:** N / Y (Y=SEE BACK) **PHOTOS:** N / Y

CAUSE OF STRANDING: 11 8p **IF CODE=10 OR 11, THEN PRIMARY:** Emaciation

OTHER SIGNIFICANT FINDINGS: Cardiomyopathy.

DISPOSITION: CARCASS: Ø PELT: Ø SKELETON: Ø SKULL: Ø BACULUM: Ø PREMOLAR: Ø 192

FACTSHEET2016_V1

CONTINUE ON BACK: N / Y

SO# 8385-17

TAG REF #: BRD 999-05

KNOWN AGE: N / Y **IF YES:** KA<3 MO KA<6 MO KA< 12MO

TAGS: R: PI / 1/2 / 213 (COL / POS / NO.; MISSING? Y / N) **L:** TQ / 4/5 / 290 (COL / POS / NO.; MISSING? Y / N) **PIT:** 44615D0F54 **WORKING:** Y / N / ?

TAG HX: Captured: 8 September 2005 @ PPE, 15.3 kg, Subadult, 2-3 years old.
Captured: 11 January 2012 @ Lucas Point, 19.0 kg, estimated 10 years.
Captured: 02 July 2015 @ Otter Point, 16.8 kg, estimated 12 years.

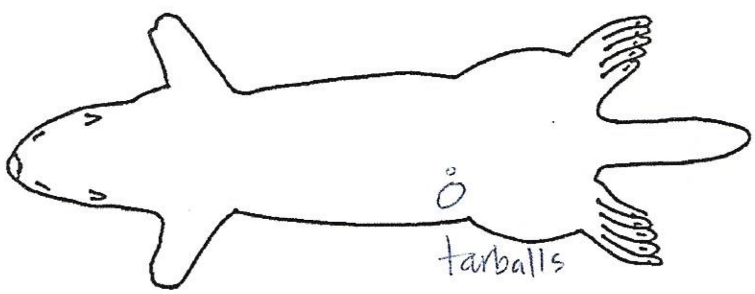
ECHINO: SKULL: 0=NONE 1=SLIGHT 2=OBVIOUS 9=? **PCS:** 0=NONE 1=SLIGHT 2=OBVIOUS 9=? REMARKS:

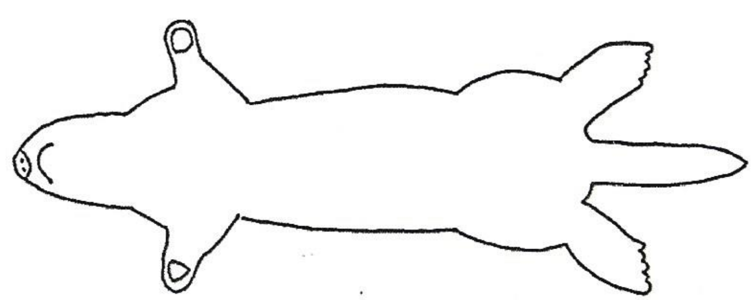
SAMPLES TAKEN: BI=BILE BL=BLOOD BR=BRAIN GC=GUT CONTENT HE=HEART KI=KIDNEY LI=LIVER LN=LYMPH NODE LU=LUNG MU=MUSCLE SP=SPLEEN UR = URINE ALL OTHER: Tarball
FOR WHAT: WHOM:

HISTO SAMPLE: FULL / PARTIAL

XRAY: NO 1=YES,GUNSHOT 2=YES,NOT GUNSHOT 3=YES,GUNSHOT:OLD HEALED WOUND

ADDITIONAL REMARKS:





BRD1260-12

STRANDED SEA OTTER FACT SHEET

SO# 8458-17

PERSON REQUESTING SO#: HATFIELD

DATE FOUND: 23 (DD) MAY (MMM) 2017 (YYYY)

MWVCRC# 170171

FOUND BY: PC RPC BO PM SBS SOB BIO UU — CUBEY

OTHER# BRD 1260

RECOVERY AREA: 29 **ATOS:** 732 **LAT / LONG (DD): N** ____ **W** ____ **TC / GE**

RECOVERY LOCATION: SAN SIMEON, SLO Co (CITY / COUNTY, LOCATION DETAILS, LANDMARKS) **TAR ON BEACH:** N / Y / ?

COND: 1=ALIVE (EUTH: Y / N) 2= FRESH 3=MOD DECOMP 4=ADV DECOMP 5=MUMM/FRAG/SKEL 9=? **SCAVENGED:** 0=NO 1= SLIGHT 2=MOD 3=HEAVILY 9=?

SEX: F / M / ? **AGE:** 2=PUP 3=IM 4 or 14 =SA 5 or 15 =AD 6=AGED AD 7=PUP OR IM 8=SA, AD, AA 9=?

TAGGED: N / Y / ? (Y=PG 2) **TAR ON OTTER:** N / Y / ? **OBV TRAUMA:** N / Y / ? **EST AGE:** 5-6 W / M / YR **BY:** C Young

TL: 116 CM **TAIL:** 29 CM **WT:** ~~12.5~~ 12.9 - 0.4 KG **NOSE WOUND: SIZE:** S **FRESHNESS:** W

TEETH: 5=ALL MILK 6=SOME MILK 1=EXC 2=GOOD 3=FAIR 4=POOR 9=? REMARKS:

ECHINO: 0=NONE 1=SLIGHT 2=OBVIOUS 9=? (SKULL OR PCS EXAMINED, SEE BACK) REMARKS:

GRIZZLE: 6=NATAL 7=JUV BUFF 1=NONE TO SLIGHT 2=TO EYES 3=TO LAMBDOIDAL CREST 4=TO CHEST 5=TO TAIL 9=?

RED ALGAE ON FUR: N / Y / ? VISUAL / UV LAMP 1=<2% 2=2-10% 3=11-20% 4=>20% REMARKS:

NECROPSY: NO / F / G / D BY WHOM: B / BP / V / VP / P E Dodd, C Young DATE: 31 May 2017

COND AT NEC: 2 / 3 / 4 / 5 **PREV FROZEN:** N / Y **LOCATION OF NECROPSY:** MWVCRC

SUBCU FAT: 0=NONE 1=SCANT 2=FAIR 3=MOD 4=ABUND 9=? **TARRY DIGESTA:** 0=NOT OBVIOUS 1=SLIGHT 2=OBVIOUS 9=?

FOOD IN GUT: 0=EMPTY 1=LITTLE 2=MED 3=FULL 9=? PREY: none

ACANTH: UNK / NO / C / P / C=P / CP / PC INT: 0=NONE 1=MILD 2=MOD 3=HEAVY 9=? AB: 0=NONE 1=MILD 2=MOD 3=HEAVY 9=?

FETUS: N=NO Y=YES, NO SEX M=YES, MALE F=YES, FEMALE U=? TL: — CM CR: — CM WT: — GM

WOUNDS CHARC OF SHARK BITE: N / Y / ? **EFFORT TO CONFIRM:** 0=NONE 1=CURSORY 2=INTENSIVE 3= NA

WOUND DESCR: 1= NO OBVIOUS HEALING 2= INDICATION OF HEALING 3= INDICATION OF INFECTION 4= OBVIOUSLY OLD, HEALED 5= ? 6=NA

EVIDENCE WOUNDS ANTE-MORTEM: Y / ? / NA IF YES: SQ HEM OTHER:

REMARKS:
BH PICKED UP. MISSING TAGS 4/5 4/5. COULDN'T GET READING ON PIT TAG.
NO INSTRUMENTS PALPATED. - FROZEN AND TRANSFERED TO CDFW-MB
MH SCANNED FROZEN CARCASS FOR PIT. - NO READING
Prominent nipples, not lactating
Mammary tissue obvious
No previous surgery
Placentation site on R horn (CAs/CLs not visible)
Mild gastric ulcers, Bloody fluid + coffee grounds in Stomach
- lower GI scavenged
- Heart small w/ mild mottling
- Very poor body condition

PREMOLAR: N / UR UL LR LL (broke, missing) **FUR:** N / Y **WHISKERS:** N / Y **OTHER SAMPLES:** N / Y (Y=SEE BACK) **PHOTOS:** ~~N~~ / Y

CAUSE OF STRANDING: 11 **IF CODE=10 OR 11, THEN PRIMARY:** ELS (End lactation syndrome)

OTHER SIGNIFICANT FINDINGS:

DISPOSITION: CARCASS: ~~B~~ Ø PELT: Ø SKELETON: Ø SKULL: Ø BACULUM: Ø PREMOLAR: Ø
FROZEN TO MWVCRC 27 MAY

CONTINUE ON BACK: ~~N~~ / Y

FACTSHEET2016_V1

JCY

PIT SLO2012057 working
Tag holes only (4/5, 4/5)

Captured 10/18/12

No SX (preg.)

BRD 1352-16

STRANDED SEA OTTER FACT SHEET

SO# 8564-17

PERSON REQUESTING SO#: Sandrine Hazan

DATE FOUND: ~~02~~ 01 (DD) Aug (MMM) 2017 (YYYY)

MWVCRC# 17-0432

FOUND BY: SBS PC RPC BO PM SOB BIO UU Tanya

OTHER# 1352-16 BRD

RECOVERY AREA: 13 **ATOS:** 369 **LAT / LONG (DD): N** 36 37.41 **W** 121 50.34 **TC / GE**

RECOVERY LOCATION: Sand City, Monterey (CITY / COUNTY) off of Tioga Rd (LOCATION DETAILS, LANDMARKS) **TAR ON BEACH:** N / Y / ?

COND: 1=ALIVE (EUTH: Y / N) 2= FRESH 3=MOD DECOMP 4=ADV DECOMP 5=MUMM/FRAG/SKEL 9=? **SCAVENGED:** 0=NO 1= SLIGHT ~~2=MOD~~ 3=HEAVILY 9=?

SEX: F / M / ? **AGE:** 2=PUP 3=IM 4 or 14=SA 5 or 15=~~AD~~ 6=AGED AD 7=PUP OR IM 8=SA, AD, AA 9=?

TAGGED: N / Y / ? (Y=PG 2) **TAR ON OTTER:** N / Y / ? **OBV TRAUMA:** N / Y / ? **EST AGE:** 3-4 W / M / YR **BY:** Miller

TL: 118 CM **TAIL:** 25 CM **WT:** — KG **NOSE WOUND: SIZE:** N **FRESHNESS:** N

TEETH: 5=ALL MILK 6=SOME MILK 1=EXC ~~2=GOOD~~ 3=FAIR 4=POOR 9=? REMARKS: ~~Could not see Molars or premolars~~

ECHINO: 0=NONE 1=SLIGHT 2=OBVIOUS 9=? (SKULL OR PCS EXAMINED, SEE BACK) REMARKS:

GRIZZLE: 6=NATAL 7=JUV BUFF 1=NONE TO SLIGHT 2=TO EYES 3=TO LAMBDOIDAL CREST 4=TO CHEST 5=TO TAIL 9=?

RED ALGAE ON FUR: N / Y / ? VISUAL / UV LAMP 1=< 2% 2=2-10% 3=11-20% 4=>20% REMARKS:

NECROPSY: NO / F / G / D BY WHOM: B / BP / V / VP / P Miller, Batac, Reed, Dodd DATE: 3 Aug 2017

COND AT NEC: 2 / 3 / 4 / 5 **PREV FROZEN:** N / Y **LOCATION OF NECROPSY:** MWVCRC

SUBCU FAT: 0=NONE 1=SCANT 2=FAIR 3=MOD 4=ABUND 9=? **TARRY DIGESTA:** 0=NOT OBVIOUS 1=SLIGHT 2=OBVIOUS 9=?

FOOD IN GUT: 0=EMPTY 1=LITTLE 2=MED 3=FULL 9=? PREY:

ACANTH: UNK / NO / C / P / C=P / CP / PC INT: 0=NONE 1=MILD 2=MOD 3=HEAVY 9=? AB: 0=NONE 1=MILD 2=MOD 3=HEAVY 9=?

FETUS: N=NO Y=YES, NO SEX M=YES, MALE F=YES, FEMALE U=? TL: — CM CR: — CM WT: — GM

WOUNDS CHARC OF SHARK BITE: N / Y / ? **EFFORT TO CONFIRM:** 0=NONE 1=CURSORY 2=INTENSIVE 3= NA

WOUND DESCR: 1= NO OBVIOUS HEALING 2= INDICATION OF HEALING 3= INDICATION OF INFECTION 4= OBVIOUSLY OLD, HEALED 5= ? 6=NA

EVIDENCE WOUNDS ANTE-MORTEM: Y / ? / NA IF YES: SQ HEM OTHER:

REMARKS:
Carcass found by Beachcombers, originally reported 01-Aug-2017 but not found until today on 02 Aug (recovered this day). No ovbvious injuries, aside from scavanging. In a cooler on ice. Sloughing fur.
All abdominal organs gone, heart gone, most of lungs gone, nutritional condition is unknown, maggots and beetles presents,

PREMOLAR: N / UR / UL / LR LL **FUR:** N / Y **WHISKERS:** N / Y **OTHER SAMPLES:** N / Y (Y=SEE BACK) **PHOTOS:** N / Y

CAUSE OF STRANDING: 3 **IF CODE=10 OR 11, THEN PRIMARY:**

OTHER SIGNIFICANT FINDINGS:

DISPOSITION: CARCASS: 0 PELT: 0 SKELETON: 192 SKULL: 192 BACULUM: 192 PREMOLAR: 192
(for colleen Young (echino Study))

FACTSHEET2016_V1

CONTINUE ON BACK: N / Y

JCY

SO# 8564-17

TAG REF #: BRD 1352 **KNOWN AGE:** N / Y **IF YES:** KA<3 MO KA<6 MO KA< 12MO est. at capture - see attached email from M. Staedler

TAGS: R: CA / 4/5 / MBA 220 (COL / POS / NO.) MISSING? Y / N **L:** OR RED? BK / 4/5 / MBA 042 (COL / POS / NO.) MISSING? Y / N **PIT:** 985141000929892 **WORKING:** Y / N / ?

TAG HX:
Captured 6/2/2016, est age 5 mo.
Pup of 6-380
Not implanted

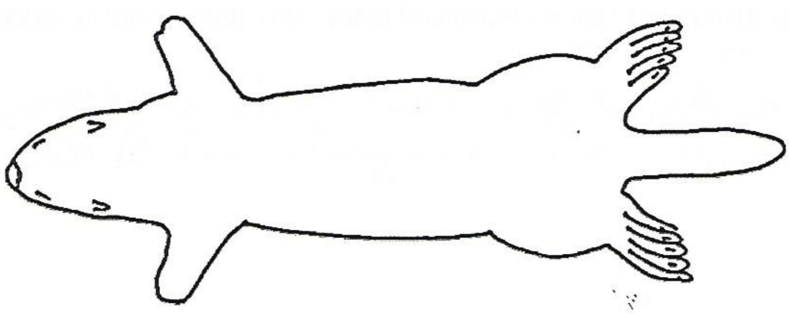
ECHINO: SKULL: 0=NONE 1=SLIGHT 2=OBVIOUS 9=? **PCS:** 0=NONE 1=SLIGHT 2=OBVIOUS 9=? REMARKS:

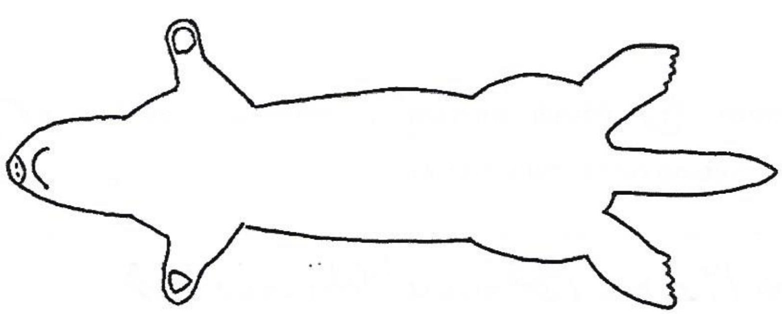
SAMPLES TAKEN: BI=BILE BL=BLOOD BR=BRAIN GC=GUT CONTENT HE=HEART KI=KIDNEY LI=LIVER LN=LYMPH NODE LU=LUNG MU=MUSCLE SP=SPLEEN UR = URINE ALL OTHER: NONE
FOR WHAT: WHOM:

HISTO SAMPLE: FULL / PARTIAL None

XRAY: 1=YES,GUNSHOT 2=YES,NOT GUNSHOT 3=YES,GUNSHOT:OLD HEALED WOUND No

ADDITIONAL REMARKS:





COPY

STRANDED SEA OTTER FACT SHEET

SO# 8606-17

PERSON REQUESTING SO#: K. Mayer

DATE FOUND: 26 (DD) Aug (MMM) 2017 (YYYY)

MWVCRC# 17-0449

FOUND BY: PC RPC BO PM SBS SOB BIO UU Nicole Capps

OTHER# BRD 1314, 175Ø655

RECOVERY AREA: 13 **ATOS:** 372 **LAT / LONG (DD): N** **W** **TC / GE**

RECOVERY LOCATION: Monterey, CA (CITY / COUNTY) Del Monte Beach, S of Tides Hotel (LOCATION DETAILS, LANDMARKS) **TAR ON BEACH:** N / Y / ?

COND: 1=ALIVE (EUTH: Y / N) 2=FRESH 3=MOD DECOMP 4=ADV DECOMP 5=MUMM/FRAG/SKEL 9=? **SCAVENGED:** 0=NO 1= SLIGHT 2=MOD 3=HEAVILY 9=?

SEX: F / M / ? **AGE:** 2=PUP 3=IM 4 or 14 =SA 5 or 15 =AD 6=AGED AD 7=PUP OR IM 8=SA, AD, AA 9=?

TAGGED: N / Y / ? (Y=PG 2) **TAR ON OTTER:** N / Y / ? **OBV TRAUMA:** N / Y / ? **EST AGE:** 7-8 W / M / YR **BY:** Batac

TL: 119 CM **TAIL:** 28 CM **WT:** 21.5 KG **NOSE WOUND:** SIZE: M FRESHNESS: W

TEETH: 5=ALL MILK 6=SOME MILK 1=EXC 2=GOOD 3=FAIR 4=POOR 9=? REMARKS: missing lower incisor

ECHINO: 0=NONE 1=SLIGHT 2=OBVIOUS 9=? (SKULL OR PCS EXAMINED, SEE BACK) REMARKS:

GRIZZLE: 6=NATAL 7=JUV BUFF 1=NONE TO SLIGHT 2=TO EYES 3=TO LAMBDOIDAL CREST 4=TO CHEST 5=TO TAIL 9=?

RED ALGAE ON FUR: N / Y / ? VISUAL / UV LAMP 1=< 2% 2=2-10% 3=11-20% 4=>20% REMARKS: a few, very small patches

NECROPSY: NO / F / G / D BY WHOM: ~~B~~ / ~~BP~~ / V / VP / ~~R~~ Batac, Dodd, Reed, Greenwald DATE: 29 Aug 2017

COND AT NEC: 2 / 3 / 4 / 5 **PREV FROZEN:** N / Y **LOCATION OF NECROPSY:** MWVCRC

SUBCU FAT: 0=NONE 1=SCANT 2=FAIR 3=MOD 4=ABUND 9=? **TARRY DIGESTA:** 0=NOT OBVIOUS 1=SLIGHT 2=OBVIOUS 9=?

FOOD IN GUT: 0=EMPTY 1=LITTLE 2=MED 3=FULL 9=? PREY: Crab,

ACANTH: UNK / NO / C / P / C=P / CP / PC INT: 0=NONE 1=MILD 2=MOD 3=HEAVY 9=? AB: 0=NONE 1=MILD 2=MOD 3=HEAVY 9=?

FETUS: N=NO Y=YES, NO SEX M=YES, MALE F=YES, FEMALE U=? TL: ______ CM CR: ______ CM WT: ______ GM

WOUNDS CHARC OF SHARK BITE: N / Y / ? **EFFORT TO CONFIRM:** ~~0=NONE~~ 1=CURSORY 2=INTENSIVE 3= NA

WOUND DESCR: 1=NO OBVIOUS HEALING 2= INDICATION OF HEALING 3= INDICATION OF INFECTION 4= OBVIOUSLY OLD, HEALED 5= ? 6=NA

EVIDENCE WOUNDS ANTE-MORTEM: Y / ? / NA IF YES: SQ HEM OTHER:

REMARKS:

Fresh dead tagged otter recovered by SORAC volunteers on Del Monte Beach. Tag combo: R 1/2 HO, L 1/2 HO. R inguinal PIT tag: 985112001034274. Unable to confirm ID in any of the databases we had access to. Female had evidence of shark bite wounds, good body condition, and no evidence of VHF transmitter that was palpable in abdomen (though did not conduct an exhaustive search). Had old, healed nose wound, grizzle appeared to be category 3.

PREMOLAR: N / UR UL LR LL **FUR:** N / Y **WHISKERS:** N / Y **OTHER SAMPLES:** N / Y (Y=SEE BACK) **PHOTOS:** N / Y

(Not collected at capture.)

CAUSE OF STRANDING: 5 **IF CODE=10 OR 11, THEN PRIMARY:**

OTHER SIGNIFICANT FINDINGS:

DISPOSITION: CARCASS: 0 PELT: 0 SKELETON: 0 SKULL: ~~10~~ 192 BACULUM: 0 PREMOLAR: 192

FACTSHEET2016_V1

CONTINUE ON BACK: N / Y

SO# 8606-17

TAG REF #: BRD 1314-13 **KNOWN AGE:** N / Y **IF YES:** KA<3 MO KA<6 MO KA< 12MO

TAGS: R: HO / 1/2 / ______ (COL / POS / NO.) MISSING? Y / N ✓Y **L:** HO / 1/2 / ______ (COL / POS / NO.) MISSING? Y / N ✓Y **PIT:** 985112001034274 **WORKING:** Y / N / ? ✓Y

TAG HX: Captured 10 December 2013, Monterey, MBIN near Plaza Hotel, 20.2 Kg, est. age 6 years.

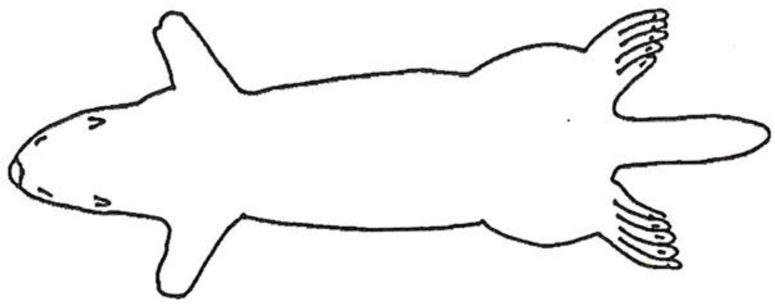
ECHINO: SKULL: 0=NONE 1=SLIGHT 2=OBVIOUS 9=? **PCS:** 0=NONE 1=SLIGHT 2=OBVIOUS 9=? REMARKS:

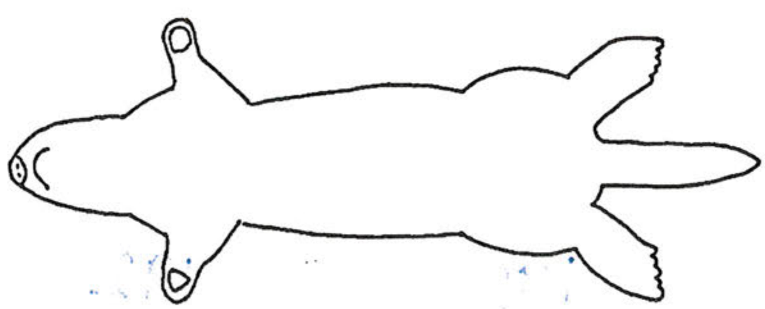
SAMPLES TAKEN: BI=BILE BL=BLOOD BR=BRAIN GC=GUT CONTENT HE=HEART K=KIDNEY LI=LIVER LN=LYMPH NODE LU=LUNG MU=MUSCLE SP=SPLEEN UR = URINE ALL OTHER:
FOR WHAT: WHOM:

HISTO SAMPLE: FULL / PARTIAL

XRAY: 1=YES,GUNSHOT 2=YES,NOT GUNSHOT 3=YES,GUNSHOT:OLD HEALED WOUND NO

ADDITIONAL REMARKS:





Vargas, Darcy <darcy_vargas@fws.gov>

question regarding transfer of sea otter samples

Vargas, Darcy <darcy_vargas@fws.gov> Wed, Jun 26, 2019 at 11:21 AM
To: "Tomoleoni, Joseph" <jtomoleoni@usgs.gov>

Hi Joe,

Unfortunately, your previously approved permit # **672624** does not authorize export under the MMPA.

Please also be reminded that we are still waiting for a copy of your 2016 & 2017 reports, along with a signed copy of your revised application (or you can resend/withdraw the updated application so that we only add your direct responses to our questions & reports to your August 15, 2018, application).

Respectfully,

Darcy Vargas
Biologist
US Fish and Wildlife Service
MS: IA
5275 Leesburg Pike
Falls Church, VA 22041-3803
www.fws.gov
www.cites.org

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If you'd like to personalize your own sentence w/ hyperlink, here's the full link: http://visitor.r20.constantcontact.com/manage/optin?v=0016mDWXmlC-eCNJ4wf_4IA3WaTa8IjzcuPb8jWWJtQIDE8kRHO2RaQ17v2A6OUJgeCSOjzrh7ruV2Nz76Ues6ALGcio28DZ6UAnX5e55gpAO4%3D

[Quoted text hidden]

Vargas, Darcy <darcy_vargas@fws.gov>

question regarding transfer of sea otter samples

Vargas, Darcy <darcy_vargas@fws.gov> Wed, Jun 26, 2019 at 11:26 AM
To: "Tomoleoni, Joseph" <jtomoleoni@usgs.gov>

Hi Joe,

I realized that I should probably send you a copy of the permit I am looking at in case you have a more updated version. The previously approved permit I reviewed and attached to this email expired in 2013.

Regards,
[Quoted text hidden]
[Quoted text hidden]

2008-10-31_672624_Final-PRT_expire-2013.pdf
399K

BISON CONNECT

Vargas, Darcy <darcy_vargas@fws.gov>

2017 Sea otter Permit report (Permit # 672624)

Vargas, Darcy <darcy_vargas@fws.gov> Fri, Jun 28, 2019 at 12:15 PM
To: "Tomoleoni, Joseph" <jtomoleoni@usgs.gov>

Hi Joe and Happy Friday,

Thank you for the 2017 report. Will will move forward without your 2016 report.

We also received your updated application, but unfortunately we are still unable to accept electronic signatures on applications. Hence, we still need a signed copy of your updated application. However, if no information is being changed from the first updated application you provided, please only reply with the signed page 1 of the application so that we can add it to your file.

Regarding your export of samples, I will reply as soon as Anna confirms/approves my response.

Regards,

Darcy Vargas
Biologist
US Fish and Wildlife Service
MS: IA
5275 Leesburg Pike
Falls Church, VA 22041-3803
www.fws.gov
www.cites.org

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If you'd like to personalize your own sentence w/ hyperlink, here's the full link: http://visitor.r20.constantcontact.com/manage/optin?v=0016mDWXmlC-eCNJ4wf_4IA3WaTa8IjzcuPb8jWWJtQIDE8kRHO2RaQ17v2A6OUJgeCSOjzrh7ruV2Nz76Ues6ALGcio28DZ6UAnX5e55gpAO4%3D

[Quoted text hidden]

Vargas, Darcy <darcy_vargas@fws.gov>

2017 Sea otter Permit report (Permit # 672624)

Tomoleoni, Joseph <jtomoleoni@usgs.gov> Tue, Jul 2, 2019 at 3:21 PM
To: "Vargas, Darcy" <darcy_vargas@fws.gov>

Hello Darcy,

I've printed, signed (in ink) and attached Page 1 of the application here. Please let me know if this works.

Thank you,

Joe
--
Joe Tomoleoni
Biologist
U.S. Geological Survey
Western Ecological Research Center
Santa Cruz Field Station
2885 Mission St.
Santa Cruz, CA 95060
office: 831.460.7447
cell: 831.254.9750
jtomoleoni@usgs.gov

[Quoted text hidden]

Page 1 Application_Signed.pdf
374K

OMB Control No. 1018-0093
Expires 08/31/2020

Department of Interior
U.S. Fish and Wildlife Service
Federal Fish and Wildlife Permit Application Form

U.S. Fish and Wildlife Service
Division of Management Authority
Branch of Permits, MS: IA
5275 Leesburg Pike
Falls Church, VA 22041-3803
1-800-358-2104 or 703-358-2104

Type of Activity

Take/Import/Export of Marine Mammals for Public Display, Scientific Research, Enhancement, or Rescue/Rehabilitation/Release Activities or Renewal/Amendment of Existing Permit (*MMPA and/or ESA*)

Complete Sections A or B, and C, D, and E of this application. U.S. address may be required in Section C, see instructions for details.
You may find instructions on how to make your application complete and help avoid unnecessary delays at the following link:

Section A: Complete if applying as an individual

1.a. Last Name		1.b. First Name	1.c. Middle Name/Initial	1.d. Suffix
Tomoleoni		Joseph	A	
2. Date of Birth (mm/dd/yyyy)	3. Telephone Number	3.a. Alternate Telephone Number	4. E-mail address	
[redacted]	831-254-9750		jtomoleoni@usgs.gov	

Section B: Complete if applying on behalf of a business, corporation, public agency, Tribe, or institution

1.a. Name of business, agency, Tribe, or institution		1.b. Doing business as (DBA)	
2. Tax identification no		3. Description of business, agency, Tribe, or institution	
4.a. Principal officer Last name	4.b. Principal officer First Name	4.c. Principal officer Middle name/initial	4.d. Suffix
5. Principal officer title	6. Primary contact name		
7.a. Business telephone number	7.b. Alternate telephone number	7.c. Business fax number	7.d. Business e-mail address

Section C: All applicants complete address information

1.a. Physical address (Street address; Apartment #, Suite #, or Room #; no P.O. Boxes)				
2885 Mission Street				
1.b. City	1.c. State	1.d. Zip code/Postal code	1.e. County/Province	1.f. Country
Santa Cruz	CA	95060	Santa Cruz	USA
2.a. Mailing address (include if different than physical address; include name of contact person if applicable)				
2.b. City	2.c. State	2.d. Zip code/Postal code	2.e. County/Province	2.f. Country

Section D: All applicants MUST complete

1. **Attach the non-refundable application processing fee,** in the form of a check or money order, payable to the U.S. FISH AND WILDLIFE SERVICE **in the amount identified on page 3.** Federal, Tribal, State, and local government agencies, and those acting on behalf of such agencies, are exempt from the processing fee – *attach documentation of fee exempt status as outlined in instructions.* [50 CFR 13.11(d)].
2. Certification: I hereby certify that I have read and am familiar with the regulations contained in ***Title 50 Part 13 of the Code of Federal Regulations*** and the other ***applicable parts in subchapter B of Chapter I of Title 50***, and I certify that the information submitted in this application for a permit is complete and accurate to the best of my knowledge and belief. I understand that any false statement herein may subject me to the criminal penalties of 18 U.S.C. 1001.

Signature of applicant/Principal Officer for permit (No photocopied or stamped signatures) Date of signature (mm/dd/yyyy)

JOSEPH TOMOLEONI Digitally signed by JOSEPH TOMOLEONI Date: 2019.06.26 15:46:44 -07'00'

7/2/19

Please continue to next page

Vargas, Darcy <darcy_vargas@fws.gov>

2017 Sea otter Permit report (Permit # 672624)

Vargas, Darcy <darcy_vargas@fws.gov> Tue, Jul 2, 2019 at 4:08 PM
To: "Tomoleoni, Joseph" <jtomoleoni@usgs.gov>

Hi Joe,

Ref: 672624

Yes, I can used your signed page 1 that was emailed today.

Would you like me to move forward with your application review or did you want me to wait for additional information regarding the export of samples to be added?

[Quoted text hidden]

[Quoted text hidden]

Vargas, Darcy <darcy_vargas@fws.gov>

question regarding transfer of sea otter samples

Vargas, Darcy <darcy_vargas@fws.gov> Tue, Jul 2, 2019 at 9:58 AM
To: "Tomoleoni, Joseph" <jtomoleoni@usgs.gov>

Hi Joe,

You would need to amend your MMPA permit to include exports before requesting a CITES permit to export the samples. I recommend updating your current application that I am reviewing now to include your export requests. If you submit the updated information, I will have to resend your application to our internal reviewers. However, your application has not been sent to the MMC yet so that part of your application review would not be affected.

Please let me know what you decide to do in regards to adding the export of samples to your application # **672624** as soon as possible so I know how to proceede.

Respectfully,

Darcy Vargas

Biologist
US Fish and Wildlife Service
MS: IA
5275 Leesburg Pike
Falls Church, VA 22041-3803
www.fws.gov
www.cites.org

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On Wed, Jun 26, 2019 at 6:57 PM Tomoleoni, Joseph <jtomoleoni@usgs.gov> wrote:

Hi Darcy,

Thank you for the information. Could you please let me know what permit application/form number we would have to complete in order to export our samples to our collaborators in Canada?

Sorry for the delay on the signing of the permit application. I didn't realize that the actual application wasn't signed. I have reattached the entire application packet here, with my signature.

The copy of the permit that you are looking at (which was attached to your most recent email from earlier today) is an older version (version 16). Our most recent permit that we are renewing is attached here in 2 versions. The first was our initial permit issued #672624-18 for the period of 2013-2018. The second attachment is our most recent revision (#672624-20), listing myself and Brian Hatfield as the permit holders.

I will send the 2017 permit report in a separate email, due to attachment size restrictions. Please let me know if you have any questions about what is included here.

Thank you,

Joe

--
Joe Tomoleoni
Biologist
U.S. Geological Survey
Western Ecological Research Center
Santa Cruz Field Station
2885 Mission St.
Santa Cruz, CA 95060
office: 831.460.7447
cell: 831.254.9750
jtomoleoni@usgs.gov

On Wed, Jun 26, 2019 at 8:27 AM Vargas, Darcy <darcy_vargas@fws.gov> wrote:

Hi Joe,

I realized that I should probably send you a copy of the permit I am looking at in case you have a more updated version. The previously approved permit I reviewed and attached to this email expired in 2013.

Regards,

Darcy Vargas
Biologist
US Fish and Wildlife Service
MS: IA
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On Wed, Jun 26, 2019 at 11:21 AM Vargas, Darcy <darcy_vargas@fws.gov> wrote:

Hi Joe,

Unfortunately, your previously approved permit # **672624** does not authorize export under the MMPA.

Please also be reminded that we are still waiting for a copy of your 2016 & 2017 reports, along with a signed copy of your revised application (or you can resend/withdraw the updated application so that we only add your direct responses to our questions & reports to your August 15, 2018, application).

Respectfully,

Darcy Vargas
Biologist
US Fish and Wildlife Service
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www.cites.org

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On Fri, Jun 21, 2019 at 2:43 PM Tomoleoni, Joseph <jtomoleoni@usgs.gov> wrote:

Hi Darcy,

We would like to send some samples (sea otter fat biopsies) to collaborators at Dalhousie Univeristy in Canada, for analysis on a joint project. These samples were taken under earlier versions of our permit (MA672624), when the permit holder was M. Tim Tinker. The permit was transferred to me in 2017, so I think I am now the responsible party.

Does our existing permit allow the transfer or these samples to our collaborators, or is there something further that needs to be done?

Thank you,

Joe

--

Joe Tomoleoni
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2885 Mission St
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office: 831.460.7447
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jtomoleoni@usgs.gov

Vargas, Darcy <darcy_vargas@fws.gov>

2017 Sea otter Permit report (Permit # 672624)

Tomoleoni, Joseph <jtomoleoni@usgs.gov> Wed, Jul 3, 2019 at 1:22 PM
To: "Vargas, Darcy" <darcy_vargas@fws.gov>
Cc: "Yee, Julie" <julie_yee@usgs.gov>, Anna Barry <anna_barry@fws.gov>

Thank you Darcy for clearing that up. I will be back in touch shortly about this.

Best,

Joe
--
Joe Tomoleoni
Biologist
U.S. Geological Survey
Western Ecological Research Center
Santa Cruz Field Station
2885 Mission St.
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office: 831.460.7447
cell: 831.254.9750
jtomoleoni@usgs.gov

[Quoted text hidden]

Vargas, Darcy <darcy_vargas@fws.gov>

2017 Sea otter Permit report (Permit # 672624)

Vargas, Darcy <darcy_vargas@fws.gov> Wed, Jul 3, 2019 at 9:13 AM
To: "Tomoleoni, Joseph" <jtomoleoni@usgs.gov>
Cc: "Yee, Julie" <julie_yee@usgs.gov>, Anna Barry <anna_barry@fws.gov>

Good morning Joe,

I checked your permit # 672624 again and I didn't see that the USGS is authorized to transfer samples to any other individual or institution.

Yes, if the samples were transferred to the Smithsonian Institute and they wanted to export them, as the new owners of the samples, they would need to submit an application for the export. However, we would not be able to authorize the export of their samples since they did not have authorization under the MMPA to acquire the samples from the USGS.

Respectfully,

Darcy Vargas
Biologist
US Fish and Wildlife Service
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www.cites.org

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On Tue, Jul 2, 2019 at 5:39 PM Tomoleoni, Joseph <jtomoleoni@usgs.gov> wrote:

> Thank you Darcy. I'm discussing the best course of action regarding the samples with our collaborators. I was hoping that there is a solution where the samples could be processed in the USA, but I'm being told that there may not be. I'm standing by for more info and will let you know as soon as we have a decision regarding the export of samples.
>
> In the meantime, it would help if we knew the following: Our collaborator that is hoping to obtain the sea otter fat samples is Kathy Ralls at the Smithsonian Institute. If we send her the samples, and she decided that they needed to be exported to Canada for processing, does the responsibility fall on Kathy/Smithsonian for obtaining the appropriate permits for export, or does the responsibility stay with us (USGS) as the original collectors of the samples?
>
> Thanks for you help with this,
>
> Joe
> --

Joe Tomoleoni
Biologist
U.S. Geological Survey
Western Ecological Research Center
Santa Cruz Field Station
2885 Mission St.
Santa Cruz, CA 95060

BISON CONNECT

Vargas, Darcy <darcy_vargas@fws.gov>

2017 Sea otter Permit report (Permit # 672624)

Vargas, Darcy <darcy_vargas@fws.gov> Fri, Jul 19, 2019 at 1:39 PM
To: "Tomoleoni, Joseph" <jtomoleoni@usgs.gov>
Cc: "Yee, Julie" <julie_yee@usgs.gov>, Anna Barry <anna_barry@fws.gov>

Hi Joe,

Ref: 672624

I apologize for our delayed response.

Yes, co-investigators listed on your permit may work with the samples, as long as that was identified in the application.

You are also correct that if samples are sent to a non-listed co-investigator or PI (anyone not identified on the permit or application form), that would be considered a transfer of the samples.

If you want to be able to share your samples with universities and/or museums, you would need to first have that condition added to your permit. You would also need to identify which universities and/or museums you would/could send samples to and under what circumstances (criteria) the samples would be shared.

I have included Anna in the "cc" of this email to ensure that everything I have stated is correct.

Please let me know if you need to add the request to be able to transfer collected samples to the Smithsonian Institute. If so, when you provide your updated information, please include as much detailed information as possible clarifying under what circumstances would samples be transferred, specifically what type of samples would be transferred, and up to what quantity of samples would be transferred per year.

Regards,

Darcy Vargas
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US Fish and Wildlife Service
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www.cites.org

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On Mon, Jul 8, 2019 at 8:45 PM Tomoleoni, Joseph <jtomoleoni@usgs.gov> wrote:

> Hello Darcy,
>
> I have a couple additional questions about sea otter samples. As you can see from our permit, we collect a lot of physical samples when we capture a sea otter. Since sea otter captures don't happen very often, and very few sea otter permits exist, we have always tried to maximize the value of having a sea otter "on the table" by taking a variety of samples. Most are used or analyzed right away for a specific project, but some are archived for later use or

analysis. We are seeking further clarification on authorizations to transfer samples. Am I correct to assume that if a listed co-investigator is working with the samples, then this is not considered a transfer of samples? Does a transfer only occur when samples are sent to a non-listed co-investigator? Since we work closely with many universities, there are often instances where a university lab or graduate student (not listed on our permit) with a specific expertise might submit a request to utilize/analyze sea otter samples collected during otter captures under our permit. Such a collaboration is always mutually beneficial and allows for analyses to be done that the USGS or listed collaborators do not have the expertise to conduct. How do we proceed in a case like this? Is the permit holder (myself in this case) allowed to oversee this work? Or is this a transfer of samples situation?

In the specific case from earlier emails I inquired about (Kathy Ralls/Smithsonian Institute), would adding Kathy as a co-investigator to the permit allow us to transfer samples to her? And if not, what would we need to do in order to send her sea otter fat samples for analysis?

Thank you in advance for helping us to make sure we are in compliance with what we are permitted to do.

Best,

Joe
--
Joe Tomoleoni
Biologist
U.S. Geological Survey
Western Ecological Research Center
Santa Cruz Field Station
2885 Mission St.
Santa Cruz, CA 95060
office: 831.460.7447
cell: 831.254.9750
jtomoleoni@usgs.gov

On Wed, Jul 3, 2019 at 10:22 AM Tomoleoni, Joseph <jtomoleoni@usgs.gov> wrote:

Thank you Darcy for clearing that up. I will be back in touch shortly about this.

Best,

Joe
--
Joe Tomoleoni
Biologist
U.S. Geological Survey
Western Ecological Research Center
Santa Cruz Field Station
2885 Mission St.
Santa Cruz, CA 95060
office: 831.460.7447
cell: 831.254.9750
jtomoleoni@usgs.gov

On Wed, Jul 3, 2019 at 6:14 AM Vargas, Darcy <darcy_vargas@fws.gov> wrote:

Good morning Joe,

I checked your permit # 672624 again and I didn't see that the USGS is authorized to transfer samples to any other individual or institution.

Yes, if the samples were transferred to the Smithsonian Institute and they wanted to export them, as the new owners of the samples, they would need to submit an application for the export. However, we would not be able to authorize the export of their samples since they did not have authorization under the MMPA to acquire the samples from the USGS.

Respectfully,

Darcy Vargas
Biologist
US Fish and Wildlife Service
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www cite org

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On Tue, Jul 2, 2019 at 5:39 PM Tomoleoni, Joseph <jtomoleoni@usgs.gov> wrote:

Thank you Darcy. I'm discussing the best course of action regarding the samples with our collaborators. I was hoping that there is a solution where the samples could be processed in the USA, but I'm being told that there may not be. I'm standing by for more info and will let you know as soon as we have a decision regarding the export of samples.

In the meantime, it would help if we knew the following: Our collaborator that is hoping to obtain the sea otter fat samples is Kathy Ralls at the Smithsonian Institute. If we send her the samples, and she decided that they needed to be exported to Canada for processing, does the responsibility fall on Kathy/Smithsonian for obtaining the appropriate permits for export, or does the responsibility stay with us (USGS) as the original collectors of the samples?

Thanks for you help with this,

Joe

--

Joe Tomoleoni
Biologist
U.S. Geological Survey
Western Ecological Research Center
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2885 Mission St.
Santa Cruz, CA 95060
office: 831.460.7447
cell 831 254 9750
jtomoleoni@usgs.gov

On Tue, Jul 2, 2019 at 1 09 PM Varga , Darcy darcy varga @fw gov wrote

Hi Joe,

Ref: 672624

Yes, I can used your signed page 1 that was emailed today.

Would you like me to move forward with your application review or did you want me to wait for additional information regarding the e port of ample to be added?

Regards,

Darcy Vargas
Biologi t

Vargas, Darcy <darcy_vargas@fws.gov>

USGS's MMPA Application # 67624

Vargas, Darcy <darcy_vargas@fws.gov> Tue, Sep 24, 2019 at 9:40 AM
To: Joe Tomoleoni <jtomoleo@ucsc.edu>

Good morning Joe,

I hope you are having a good week.

Please understand that because your application has been incomplete for almost 6 months now (since April 1, 2019), we must move forward with your application review or close it as an abandoned file. Therefore, please reply to let us know if your application request includes exports and if so, ensure to provide answers to all relevant export questions on application form 3-200-43 by **October 1, 2019**. If we do not receive updated information by then, we will move forward on your application request without consideration to authorization of exports.

Respectfully,

Darcy Vargas
Biologist
US Fish and Wildlife Service
MS: IA
5275 Leesburg Pike
Falls Church, VA 22041-3803
www.fws.gov
www.cites.org

Vargas, Darcy <darcy_vargas@fws.gov>

USGS's MMPA Application # 67624

Joe Tomoleoni <jtomoleo@ucsc.edu> Tue, Sep 24, 2019 at 2:56 PM
To: "Vargas, Darcy" <darcy_vargas@fws.gov>
Cc: "Yee, Julie" <julie_yee@usgs.gov>

Hi Darcy,

Thank you very much for your message about our permit application. At this time, we will not be seeking permission to export samples. We will likely being requesting permission to transfer some subset of samples to a collaborator at the Smithsonian Institute (Dr. Kathy Ralls, per our earlier emails), but for now, we do not plan to export samples outside of the U.S.

Thank you and please let me know if you have any additional questions,

Joe

Joe Tomoleoni
Biologist
U.S. Geological Survey
Western Ecological Research Center
Santa Cruz Field Station
2885 Mission St.
Santa Cruz, CA 95060
831.254.9750
jtomoleo@ucsc.edu

[Quoted text hidden]

MMPA application # 672624

Vargas, Darcy <darcy_vargas@fws.gov>
Fri 3/27/2020 11:44 AM
To: Tomoleoni, Joseph A <jtomoleoni@usgs.gov>

Dear Joe,

Ref: MMPA application # 672624

All of of our required reviews for the referenced application request have been completed. The final remaining questions for your attention are listed below. As soon as you reply, we will publish your entire application in the Federal Register.

1. You state that an otter recently died due to both a TDR and VHF becoming entrapped in the omentum. Even without the use of TDRs, do you have any concerns about this happening again if you continue to instrument otters with VHF tags?
2. Please provide a response to Q5. Since you are working in Monterey Bay, you may need a permit or will at least need to alert the Sanctuary that you will be working in the bay.
3. You state on pg 2 of the revised application that otters may have "some entanglement of one or both of the implanted instruments within the omentum" yet it appears that you have only requested implanting VHF tags under this permit. Please clarify how many tag types may be implanted. Additionally, if an otter was recently found dead because of the rare physiological impact you describe, are you concerned that even implanting otters with just VHF tags could lead to future mortalities? (Q6b).
4. Please specify what behaviors will be used to denote that disturbance has occurred due to research activities, and which behaviors will prompt a research team to vacate an area during captures with both Wilson traps and tangle nets. This should be specified for both ground and possible vessel surveys as well. (Q6c).
5. Please describe the mitigation measures that will be implemented if an otter reacts negatively to being restrained or sedated after capture (Q6d).
6. Please specify whether you will avoid non-target species at a certain distance (e.g., 100 m) or whether you will vacate an area as soon as possible if non-target species are encountered during your work (Q9b-c).
7. Please state how often tangle nets will be physically tended. (Q10a).
8. Please specify how many people would be involved with a tangle net capture (Q10d).
9. Although the application indicates that females with newborn or very small pups (1-2 weeks of age) would be avoided, what measures would be implemented in the event a female and her newborn or very small pup is accidentally captured (i.e., immediate release of both together)? (Q10gi).
10. What measures would be included if capture is interfering with vital functions such as nursing or pair bonding? Specify whether the activities will be aborted (Q10gi).
11. Please explicitly state the minimum age/size of a pup that could be sedated and sampled. Would any be sampled without sedation? (Q10gii).
12. Please clarify which procedures would be conducted under the lower dose of sedation and which would be conducted under the higher dose (Q10hii).
13. There may not be sufficient justification for the collection of the numerous different types of samples. The only mention of the use of each sample is provided in Table 1. Please provide a brief

description of the purpose of the samples to be collected and how those samples will help inform your objectives and hypotheses (Q18).

14. Please provide an explanation of how sample sizes/take numbers were determined (Q18d).
15. Since you have clarified that exports are not being request. Please provide a description of the disposition of remaining samples once the project is complete. It is acknowelged that some samples would like to be transfered domistically. However, please ensure to have provide the names and location of every institution you are requesting to transfer samples to, and also include what would be done with samples that are not transferred to other facilities.
16. Would near-term pregnant females be implanted with VHF tags? USGS's recent permit application #067925 on northern sea otters explicitly stated that near-term pregnant females would not have instruments implanted due to potential risk of post-surgical dehiscence (Q20e).
17. Since you state in response to Q20gi that vessel surveys may be conducted, potential disturbance of otters from vessel surveys may occur and takes are thus needed. Please respond accordingly to Q20bi-v.
18. Please briefly describe the methods used capture and restrain an otter and specify what measures would be implemented to ensure that individual otters are not recaptured unnecessarily (Q20d).
19. From where on the body will blood be drawn? (Q20fv)
20. How will the various samples be preserved? (Q20fxiii)?
21. How will you approach otters during vessel surveys and will you distinguish between otters that are resting versus active (e.g., swimming, traveling)? What mitigation measures will be implemented if a reaction is noted by an otter in response to vessel presence? Will you approach a hauled out otter during ground surveys? (Q20gi)
22. Since takes of otters are needed for vessel surveys and possibly ground surveys if you plan on approaching hauled out otters, please specify whether 100 m would be the absolute minimum approach distance to an otter either on foot or by vessel. If you plan on using a different minimum approach distance, please explicitly state what that distance will be to resting otters (Q20gii).
23. Please confirm if the following statement is accurate. If not, please provide clarification (your application table doesn't indicate such, but other application information does).
    - Pups less than 11 lbs will be avoided for all sampling, sedation and instrumentation procedures, pups less than 20 lbs will be avoided for instrumentation, and near-term pregnant females will be avoided for instrumentation.
24. How pregnant female will be deemed near-term if you plan on excluding them (e.g., with ossified fetus skull the size of a lemon)?
25. Why do you plan on anesthetizing/flipper tagging/sampling only half of the animals you expect to capture? Are you accounting for incidental captures or captures of pups less than 11 lbs? Please clarify.
26. It is not clear how 1,250 was determined to be the total number of non-target otters harassed by captures. Please provide the justification for this number in the application.
27. On your application table, please indicate the number of otters that may be disturbed by vessel or ground surveys in a year.
28. How would you ensure that a female and her pup are not separated during vessel surveys? (Q22)
29. As mentioned previously, please also explicitly state the minimum age/size of a pup that could be sedated and sampled (Q22-23).
30. As mentioned previously, please clarify whether near-term pregnant females could be instrumented if captured and how such a female would be deemed near-term (Q23).
31. How will you minimize impacts to non-target individuals during tangle net activities, including both incidental net captures and incidental harassment during net tending? (Q24)
32. Please state whether a necropsy would be conducted on an otter in the event of a death (Q27).

33. It is unclear whether the source of the specimens could include animals killed incidental to legal commercial fishing operations. Please provide clarification.

Respectfully,

Darcy Vargas
Biologist
US Fish and Wildlife Service
MS: IA
5275 Leesburg Pike
Falls Church, VA 22041-3803
www.fws.gov
www.cites.org

Re: MMPA application # 672624

Tomoleoni, Joseph A <jtomoleoni@usgs.gov>

Thu 5/21/2020 6:50 PM

To: Vargas, Darcy <darcy_vargas@fws.gov>
Cc: Yee, Julie L <julie_yee@usgs.gov>

1 attachments (51 KB)

2020_March_USFWS Permit Reviewer Question Responses.docx;

Hello Darcy,

My apologies for the delay in responding to the additional reviewer questions for our permit application. We've replied in the attached word document. Please let me know if any clarification is needed on any of our responses.

Thank you,

Joe

Joe Tomoleoni
Biologist
Dive Safety Officer (Southwest Region)
USGS - Western Ecological Research Center
2885 Mission St., Santa Cruz, CA 95060
O: 831.460.7447 C: 831.254.9750
jtomoleoni@usgs.gov

From: Vargas, Darcy <darcy_vargas@fws.gov>
Sent: Friday, March 27, 2020 8:44 AM
To: Tomoleoni, Joseph A <jtomoleoni@usgs.gov>
Subject: MMPA application # 672624

Dear Joe,

Ref: MMPA application # 672624

All of of our required reviews for the referenced application request have been completed. The final remaining questions for your attention are listed below. As soon as you reply, we will publish your entire application in the Federal Register.

1. **You state that an otter recently died due to both a TDR and VHF becoming entrapped in the omentum. Even without the use of TDRs, do you have any concerns about this happening again if you continue to instrument otters with VHF tags?**
2. **Please provide a response to Q5. Since you are working in Monterey Bay, you may need a permit or will at least need to alert the Sanctuary that you will be working in the bay.**
3. **You state on pg 2 of the revised application that otters may have "some entanglement of one or both of the implanted instruments within the omentum" yet it appears that you have only**

Responses to March 27, 2020 questions for renewal of USFWS MMPA Permit #672624

1. **You state that an otter recently died due to both a TDR and VHF becoming entrapped in the omentum. Even without the use of TDRs, do you have any concerns about this happening again if you continue to instrument otters with VHF tags?**

   It's important to note that instrument entrapment in the omentum appears to be a rare event, as many hundreds of sea otters have been implanted with TDRs and VHFs (and hundreds more with just VHF transmitters). In the recent instrument-related mortality it is true that both instruments (VHF & TDR) were entrapped in the omentum. However, the necropsy revealed that it was the initial entrapment of the TDR and adhesion of the omentum to the chest wall (at the TDR implant site) that created a "stalk" which in turn, resulted in the entrapment of the VHF transmitter. In other words, if the TDR complication had not occurred, there is no reason to think that the VHF would have become entrapped. Therefore, we decided to suspend TDR implants until additional information can be gathered and analyzed regarding the risk of continuing to use this model of TDR in sea otters. We do not have any concerns about VHF entrapment in sea otters that do not also have implanted TDRs.

2. **Please provide a response to Q5. Since you are working in Monterey Bay, you may need a permit or will at least need to alert the Sanctuary that you will be working in the bay.**

   We been in contact with the MBNMS permit office and have learned that most of our activities do not require a sanctuary permit; however, tags are considered by the sanctuary to be "discharge" and thus require permitting. We are in the process of obtaining a MBNMS permit to place tags on sea otters within the sanctuary.

3. **You state on pg 2 of the revised application that otters may have "some entanglement of one or both of the implanted instruments within the omentum" yet it appears that you have only requested implanting VHF tags under this permit. Please clarify how many tag types may be implanted. Additionally, if an otter was recently found dead because of the rare physiological impact you describe, are you concerned that even implanting otters with just VHF tags could lead to future mortalities? (Q6b).**

   Our previous permit allowed us to implant both VHF transmitters and TDRs in sea otters. We are seeking a renewal of this permit. However, given the circumstances surrounding the recent sea otter mortality, we have elected to suspend TDR implants while we perform a thorough examination of several decades of TDR implant and necropsy data. At this time, we are only requesting the ability to implant VHF transmitters (1 instrument type). If additional research determines that TDR use is safe in sea otters (by statistical analysis, modification of instrument size and shape, modification of surgical implant procedure, or other modification that may render the

TDRs safe to use), we may request permission to resume TDR implants in the future via a permit amendment. As stated in the response to question #1, we are not concerned about possible complications with the VHF transmitter because the VHF entrapment in the recent mortality was caused by the initial entrapment of the TDR. There is no reason to believe that the VHF would have been a problem if not for the initial TDR problem. Additionally, VHF transmitters have been successfully implanted in more than 1,000 sea otters over 30 years, providing a very large sample size (especially for marine mammals) demonstrating the efficacy and safety of this instrument and tagging method.

4. **Please specify what behaviors will be used to denote that disturbance has occurred due to research activities, and which behaviors will prompt a research team to vacate an area during captures with both Wilson traps and tangle nets. This should be specified for both ground and possible vessel surveys as well. (Q6c).**

   We state that disturbance will occur, because we are capturing wild sea otters. In our response to Q6c, we discuss disturbance to all sea otters (both target and non-target otters). When capturing sea otters with diver-operated Wilson Traps, disturbance to non-target otters is obvious as the otter(s) generally dive or swim away immediately. This cannot be avoided when sea otters are resting in close proximity to one another. However, when possible we target otters resting in smaller groups since this increases our chance of successfully capturing our target otter(s) while also minimizing the number of sea otters incidentally disturbed. Most disturbances are of very short duration (less than 30 min) since the dive boat arrives within a minute or two of capture, and once the divers and captured otter(s) are aboard, the boat departs the area (usually within 5-10 minutes from the time of capture/disturbance). The successful capture of sea otters is predicated on causing no disturbance up until the moment of capture. At that point, disturbance occurs and we attempt to mitigate the disturbance by departing the area rapidly, ideally targeting smaller groups of otters, and taking approach and departure routes that minimize additional disturbance of other otters in the area.

   Capturing sea otters with tangle nets is less selective and disturbance is more difficult to control. We can take some of the same precautions when setting and retrieving the nets (approach and departure routes that avoid otters); however, we don’t have any control over which otters are captured and which avoid the nets. Because of a variety of reasons, including less selective capture of sea otters, we only employ the use of tangle nets when dive captures are not possible (e.g. water visibility <2 ft, too dangerous to deploy divers). In practice, tangle nets are rarely used for sea otter capture in California, but under certain specific situations, they are the only method available.

   There is no potential for disturbance of sea otters during ground-based surveys. Our observers use binoculars and high-powered Questar spotting scopes (up to 80x magnification) and in 40 years of sea otter work, we have never noticed an issue with disturbance from ground-based surveys. Observers are too far away to be a concern and the sea otters are completely unaware of the presence of our shore-based surveyors or data collectors.

Boat-based surveys do have the potential to disturb sea otters if the boat gets too close. Conducting boat-based sea otter surveys presents less risk for sea otter disturbance than any other general or recreational boating occurring in the area because during surveys we are actively looking for sea otters and able to avoid them or give them a wide berth. Disturbances tend to only occur when a boat stops too close to an otter raft or passes very close at high speed. When conducting boat-based surveys we maintain a reasonable distance from sea otters but generally continue moving on steady predictable courses to minimize disturbance. Erratic boat behavior (rapid speed shifts and direction changes) has a higher potential for disturbance so we keep the boat moving slow and steady. We keep an eye out for early signs of disturbance (sea otters looking in the direction of the boat, or a behavior change from resting to sculling), and if we see any of these signs, we modify our behavior (usually increase distance between the boat and the otters) to avoid further disturbance.

5. **Please describe the mitigation measures that will be implemented if an otter reacts negatively to being restrained or sedated after capture (Q6d).**

Untoward responses to restraint and sedation are uncommon. Should they occur, the attending veterinarian will respond utilizing traditional medical paradigms of observation, assessment, and plan for action. Emergency protocols tend to be well imbedded into veterinary clinical medicine and are based on the standard A-B-C-D (airway-breathing-circulatory-drugs) approach. Crash kits consisting of a spectrum of emergency drugs, supplies, and equipment are always complete, up to date, and readily available whenever sea otters are going to be handled and/or sedated. In addition to traditional methods, the sedative combination routinely used in sea otters, fentanyl citrate and midazolam hydrochloride, can be pharmacologically reversed with naltrexone and flumazenil. Once administered, otters are typically awake and return to normal behaviour within 1-2 minutes.

6. **Please specify whether you will avoid non-target species at a certain distance (e.g., 100 m) or whether you will vacate an area as soon as possible if non-target species are encountered during your work (Q9b-c).**

Q9b-c refers to capturing wild animals and bringing them into a captive environment for public display, research, or MMPA enhancement activities. This does not apply to our permit which captures wild otters and releases them back into the wild after tagging.

We think this might refer to Q7b-c, which deals with the harassment of non-target marine mammals and ESA-listed species. In this case, we have stated that we do not expect to harass any non-target marine mammals. Diver-based Wilson Trap capture is predicated on being undetected, and the actual capture is highly selective (0% chance of catching any species other than a sea otter). Because harbor seals are frequently observed using the same kelp beds as resting sea otters, we cannot vacate the area if harbor seals are nearby in the water and still have a successful sea otter capture operation. We can (and will) avoid harbor seal haul outs and rookeries. Our diver-based sea otter captures will not (0% chance) accidentally capture harbor seals, and because the success of our diver-based captures rely on being undetected by both sea otters and other wildlife, they also have very low potential to disturb seals. In fact, on a few occasions the divers have passed directly underneath harbor seals sleeping at the surface, and since the rebreathers are silent and bubble-less, the seals remained asleep and undisturbed. Having a boat in the area could present some possibility of minor disturbance to a nearby seal in the water, but since we are moving quietly and slowly in an attempt to remain undetected by nearby otters, we think the potential of disturbing seals remains low, and is in fact, lower than other non-research vessels working or recreating in the area. The fact that we are actively taking precautions to avoid disturbance of all wildlife in order to remain undetected, and actively looking for marine mammals (from far away with binoculars) is further evidence of this assertion. We will do our best to navigate around or away from seals if they are seen along our approach path. Other marine mammals (sea lions, whales, and dolphins) are typically transiting through the area quickly, and we can wait until these animals vacate the area before putting a dive capture team in the water, though there is unlikely to be any disturbance associated with these species. We suggest that special restrictions or avoidance measures beyond what we are already doing are not likely to result in lower disturbance and have the potential to negatively impact our sea otter captures.

Although tangle nets are less selective and have a higher potential to harass or disturb non-target marine mammals or ESA-listed species, the risk remains very low. However, since the risk is not zero, we take several precautions to minimize this risk. As stated in the application, we will avoid setting nets when sea conditions prevent them from being tended (monitored by a nearby boat). When tangle nets are deployed, they will be monitored by 2 shore-based observers in order to detect the presence of non-target marine mammal species in the area. If a non-target marine mammal species is detected the tending skiff will move into position alongside the net and either pull the net from the water or stand by until the non-target animal vacates the area. Additional precautions are described in our reply to Q7b.

In general, the potential for overlap between sea otters and non-target marine mammal species or ESA-listed species is low, with a few exceptions. Harbor seals, and to a lesser extent, California sea lions, do co-occur in the same habitat as sea otters. We will not deploy nets within 100m of any pinniped, and if a pinniped approaches the net, our boat tender team or shore based observer team would be able to detect this and the boat can move into place and take the appropriate action (stand by next to the net until the pinniped departs, or pull the net if necessary). Although whales aren't commonly encountered in the shallow waters where sea otters typically occur, we do see them in or near the kelp beds on rare occasion. A net will never be deployed if there is a single whale in the vicinity. Although dolphins generally appear to be able to avoid the nets, we will also not deploy nets when dolphins are visible in the area. If a cetacean comes within 250m of a deployed net, the tender boat will move into position alongside the net and be prepared to pull the net if necessary.

7. **Please state how often tangle nets will be physically tended. (Q10a).**

   Tangle nets are constantly tended. Any time a net is deployed shore-based observers will visually tend the net. A tender boat will also be in the vicinity at all times to respond to the capture of sea otters or the presence of non-target species. The tender boat must be far enough away from the net so as not to discourage sea otters from approaching the net; however, in most instances the tender boat is also able to monitor the net from a distance with binoculars. As a result, the net is constantly tended by both a shore team and a boat team. No tangle net will ever be left unattended while deployed.

8. **Please specify how many people would be involved with a tangle net capture (Q10d).**

   For a single tangle net, 2 shore-based observers will monitor the net at all times. The tender boat would have a minimum of 2 people on board, but typically will have 3 or 4 people. Usually we have additional boats in the area that can be called in for further assistance if needed.

9. **Although the application indicates that females with newborn or very small pups (1-2 weeks of age) would be avoided, what measures would be implemented in the event a female and her newborn or very small pup is accidentally captured (i.e., immediate release of both together)? (Q10gi).**

   If a female with a newborn pup is captured the mom and pup will be immediately released together.

10. **What measures would be included if capture is interfering with vital functions such as nursing or pair bonding? Specify whether the activities will be aborted (Q10gi).**

    We believe that no special restrictions are necessary to avoid capture of pair-bonded otters or nursing pups. The holding time for captured otters is short (a few hours typically). For pair-bonded otters, they will be released in the same location where they were captured, where they can (and do, based on years of experience capturing otters and intensive post-release monitoring) resume pair-bonding. For nursing pups, there is no need to restrict capture as long as they are caught together with their mom. If one (but not both) of the mother-pup pair is caught, the captured otter will be immediately released (usually within seconds) to reunite with the other. If caught and processed together, the mom and pup will be released simultaneously, and the pup can resume nursing after release. However, in our experience the otters are usually very calm while being held in the box. It is common to observe the pup nursing while being held together with its mom in the same box. Any disruption of essential behavior such as nursing is very brief and temporary, and unlikely to have any meaningful biological impact.

11. **Please explicitly state the minimum age/size of a pup that could be sedated and sampled. Would any be sampled without sedation? (Q10gii).**

    In theory, pups of any age can be sedated and sampled. As a part of the sea otter stranding program at the Monterey Bay Aquarium, otters as young as one day of age and weighing 1-2 kg have been safely sedated and blood sampled. We are proposing to avoid sampling or sedating pups less than 11 lbs, unless there is a medical indication to do so. Such an indication may include anomalies such as pre-existing injuries, fishing gear entwinement, oral foreign body.

    Please clarify which procedures would be conducted under the lower dose of sedation and which would be conducted under the higher dose (Q10hii).

    The lower end of the dose range (0.22 mg/kg fentanyl / 0.07 mg/kg midazolam) is more accurately described as an immobilization dose. Procedures that would be considered either painless or causing only momentary discomfort, such as nasal/rectal swabs, fur/whisker collection, blood collection, flipper tag application. The use of chemical immobilization is preferable to physical restraint for both human and animal safety and welfare.

    The higher dose range (0.33 mg/kg fentanyl / 0.11 mg/kg midazolam) is reserved for painful procedures, such as transmitter implantation or other invasive, surgical procedures.

12. **There may not be sufficient justification for the collection of the numerous different types of samples. The only mention of the use of each sample is provided in Table 1. Please provide a brief description of the purpose of the samples to be collected and how those samples will help inform your objectives and hypotheses (Q18).**

    Since wild sea otter capture is a major operation that is time consuming, expensive, and potentially stressful, our research projects aim to maximize the data gathered by identifying multiple objectives. Each study (and capture event) aims to address questions about sea otter health, disease, survival, population biology, behavior, and ecology. Each sample listed in Table 1 is necessary to address these critical areas of understanding and provides us with information on individual sea otters as well as population level data and trends. Most of these samples have been taken in all past sea otter capture studies for more than 30 years. Continuing to permit the collection of the same samples allows us to perform comparison studies between different time periods. These types of longitudinal comparisons are one of the most valuable scientific tools available for assessing change in sea otter sub-populations (in different regions of

California). Sea otter populations are constantly undergoing change as prey resources fluctuate, episodic mortality events (disease, predation, etc.) occur, and environments change (ENSO events, kelp loss, sea level rise, etc.).

To present just one of many possible examples: we list the possibility of future captures at San Nicolas Island under this permit as part of a current sea otter monitoring project. Sea otter captures were last conducted at San Nicolas Island in the early 2000's, nearly 20 years ago. At that time, most or all of the samples listed in Table 1 were taken. Resampling from this sea otter sub-population 20 years later is one of the best ways of determining the health and status of this group of sea otters. In the early 2000's, the population was small (approximately 35 individuals), while the population today has more than tripled. By comparing the samples listed in Table 1 between these two time periods, we can assess change in a variety of important metrics such as:

- Changes in sea otter diet composition
- Changes in prey resource abundance and availability (as a result of increased sea otter densities or possibly by other extrinsic factors)
- If disease or contaminant exposure has become more or less important in the last 20 years
- How body condition has changed, which is a strong indicator of both sea otter and ecosystem health

In addition to the ability to assess longitudinal change in sea otter populations, we also design studies that directly compare two sub-populations during the same time period. Our Big Sur – Monterey comparison study (Tinker et al. 2019) was designed to do just that. This study was designed to investigate the "clean ocean-dirty ocean hypothesis" under the premise that sea otters in the relatively pristine waters of Big Sur would be healthier than the otters residing in the more impacted waters off Monterey. In this study all the samples from Table 1 were taken in both locations and provided the data necessary to thoroughly assess the health of individual sea otters and to compare the health of the two sub-populations with respect to their environment. This study was unprecedented in sea otters, and to date, remains the largest site-to-site comparison study of its kind, and has largely defined much of what we know today about sea otter health, population biology, and ecology in California.

We hope that DMA recognizes the tremendous contributions that biological sampling of sea otters has made to enhancing our understanding of sea otter biology. We are seeking permission to continue taking all the samples we were previously authorized to take (note, no new sample types are being requested) in order to maintain the continuity of our research program and to ensure that valuable longitudinal comparison studies will continue occur with the goal of monitoring change in sea otter individuals, populations, and in the nearshore marine environment. With rapid and extreme changes in climate, weather, habitat loss, biodiversity loss, sea level rise, ocean acidification, and more, monitoring change and the effects of change on critical keystone species like sea otters, is more important than ever.

During the course of our research, if new tools become available, or new data are acquired that makes the collection of a certain sample type no longer necessary, we will modify our approach accordingly. For example, we have a publication that is currently *in press* that describes "field aging" as a more consistently accurate aging metric in California than cementum aging (via tooth extraction). In this case, we would opt not to extract a premolar tooth for aging if a reliable field age can be determined. We still request permission to take a premolar tooth for aging in this permit renewal application, in the event that the circumstances don't allow for an accurate field age estimate.

Please refer to Table 1 for details on how each sample will be used. Additionally, please refer to the "list of relevant publications" included in our permit application packet. Most of the references utilize one or more of the sample types listed in Table 1 and provide a comprehensive rationale for the taking of these samples.

Sea otter captures are both expensive and involve some degree of risk to both the humans and animals involved. While these risks are routinely evaluated and mitigated, it would be irresponsible not to take advantage of the opportunity provided by having the otter in hand. One such opportunity is to collect, process, and properly archive a suite of biological material which may be useful at some point in the future for retrospective evaluation of health or other parameters. Future investigators may have tools, diseases, or other circumstances for which a robust inventory of historical samples may be important. It goes without saying, however, that the sample inventory described for archive consists of those biological samples which can be collected without harm to the otter.

13. Please provide an explanation of how sample sizes/take numbers were determined (Q18d).

We propose over the next 5 years to capture sea otters for tagging and bio-sampling in order to characterize basic measures of population vital rates (e.g. survival, reproduction), behavior (e.g. diet and home range use) and individual health parameters (e.g. seroprevalence for various pathogens, tissue contaminant loads, etc.). Statistical power analyses can be useful for determining adequate sample sizes (numbers of sea otters captured) to achieve reasonably accurate estimates, however they often require a fair amount of preliminary information and proper power calculations are typically as complex as the analysis itself. As a starting point, we used a power analysis for simple probability estimates (e.g. survival and reproduction rates) to determine sample sizes that would achieve a 0.05 margin of error (i.e. 95% confidence intervals no wider than 0.10) when estimating binomial probabilities.

The standard variance associated with a binomial proportion, p, is $p(1-p)/n$, and the associated 95% confidence interval is $p \pm 1.96\sqrt{p(1-p)/n}$ when using a normal approximation. The margin of error in this interval is $1.96\sqrt{p(1-p)/n}$ which we set to 0.05, and after solving for n we have that $n \geq 1.96^2 p(1-p)/0.05^2$ which depends on the very same p that we are trying to estimate. Because the rate of success, p, isn't known in advance, we conservatively set $p(1-p)$ to its maximum possible value (0.25

which is attained when p=0.5) and calculate a sample size of 381 sea otters. Because male and female sea otters exhibit different behavioral traits and energetic needs, we would propose to independently estimate their rates with a total sample size of 762 when the total population size of sea otters is unknown.

When sampling from a known population size we may apply a finite population correction (FPC) factor which corrects the variance to account for smaller sampling variation the closer the sample size is to the population size. For a population of size N, the FPC factor is the proportion of the population that is unsampled, $(1-\frac{n}{N})$, and the corrected variance is $p(1-p)(1-\frac{n}{N})/n$. For example, when sampling twenty percent of the population then the FPC is 0.8 the variance is reduced by 20%, and when sampling the entire population then the correction factor is 0 and the variance completely disappears. When using FPC, a specific margin of error can be achieved with a smaller sample size than when not using FPC. Based on the 2019 population census estimate of approximately 3000 sea otters, which we assume to be roughly equally divided by males and females, we set $N = 1500$, applied FPC to the variance, and again solved for n to obtain a sample size of 306 each for males and females, or a total sample size of 612.

Based on the power analysis with FPC, we propose to capture up to 600 animals over the next 5 years, assuming they are distributed as 120 animals per year, which represents about 4% of the current total population per year. The actual number captured is likely to be considerably less than 600 because sea otter captures only occur for funded projects, and the sample sizes for proposed projects are often constrained by numerous other practical and research-related factors. In general, sample sizes were/are designed to be similar to samples sizes from previous sea otter tagging/tracking studies that we have conducted. Most previous tracking studies start with an initial sample size of 20-30 individual sea otters; however, as studies progress and study animals die, we often perform a new round of captures to add 5-10 (or whatever number required) new sea otters to bring our standing sample size back up to that of the original sample size. Estimated sample sizes also take into account sea otter population density at the study site (higher densities of otters can result in a high capture success rate and a larger sample size). Funding also dictates sample sizes, to an extent. The instruments (VHF, TDR, new smart flipper tags) are the most expensive part of sea otter capture and tagging, so the number of instruments we can purchase will also inform sample size for some tracking studies.

In the permit application we have submitted details for 3 research projects. The Monterey NSF Predator Diversity study has mostly concluded at this point and we have no plans to capture new sea otters to add to this study. However, we do have numerous tagged study animals that still have implanted TDRs, so we plan to conduct several re-capture events in an effort to explant these remaining TDRs and retrieve those data.

The San Nicolas Island Sea Otter Population Monitoring Project is on-going with no foreseeable end date. Although this project only involves observational sea otter work at this point, the project plan contains a set of criteria that could trigger the need for sea otter capture and tagging at San Nicolas Island. Should those criteria be met, we have proposed capturing 25 sea otters at San Nicolas Island. This sample size fits within the range of prior studies. During this study, the goal of tagging would be to monitor for population level effects that could be contributing to unusual mortality events, unexplained population declines, or mortalities related to Navy activities. In order to accurately determine the cause of any of the above triggers, a substantial proportion of the population would need to be tagged. A proposal of 25 tagged otters represents just under 25% of the total population at San Nicolas. This proportion is (a) a feasible number for capture, (b) is large enough to be representative of the entire sea otter population at San Nicolas Island, which is critical to determining causes in mortality and/or population decline and (c) strikes a balance where a representative sample of the SNI sea otter population is tagged without the need for tagging and tracking all (or most) of the otters at San Nicolas Island.

The third project proposal is a new tagging technology project. The first deployment of these new e-flipper tags on wild sea otters will likely be done as a smaller pilot study (approximately 10 sea otters). The pilot study would take a proof-of-concept approach and would ideally demonstrate that the new tags are functioning properly and communicating with base stations and gateways. Because this is a pilot study, large scale deployment of tags (capture of many otters) is not required; however, the sample size of tagged otters needs to be large enough to make sure that some of the animals are regularly coming within range of a base station. Therefore, we determined that approximately 10 sea otters would be a reasonable number of otters for a new tag tech pilot study. If the pilot study is a success, large scale deployments of these non-invasive tags will be proposed for future work throughout the range of the sea otter.

The additional "takes" requested in this permit take into account numerous re-capture efforts to preform "tag maintenance" (repair or replacement of tags as needed), recover/explant TDRs for sea otters that currently have them, or to perform new captures to boost sample size if a number of otters have died or disappeared after a couple years. Additionally, on-going research on the Monterey Peninsula (in partnership with the Monterey Bay Aquarium and California Dept. of Fish & Wildlife) consists of low-level monitoring of local sea otters (some of which are study animals from earlier studies) in the vicinity of the Monterey Bay Aquarium. These otters also require routine tag maintenance and contributed to the calculation of our total take number over 5 years.

14. **Since you have clarified that exports are not being request. Please provide a description of the disposition of remaining samples once the project is complete. It is acknowelged that some samples would like to be transfered domistically. However, please ensure to have provide the names and location of every institution you are requesting to transfer samples to, and also include what would be done with samples that are not transferred to other facilities.**

USGS only maintains and stores sea otter teeth taken for aging, which are eventually to Matson Labs for cementum aging. All other samples will be transferred to other facilities for processing, analysis, or storage.

Whole blood, blood smears, and serum are sent to a veterinary reference lab (typically Idexx Laboratory) for analysis. Samples are not returned from the lab; they are discarded on site. A second set of blood smears are maintained at the Monterey Bay Aquarium. Additionally, fur samples and whiskers are kept in dry storage at the Aquarium.

Co-investigators (Francesca Batac, Melissa Miller, Colleen Young) from the California Department of Fish and Wildlife store and maintain remaining serum, plasma, packed red blood cells, whole blood, and fecal samples at the CDFW Marine Wildlife Veterinary Care and Research Center (MWVCRC) in Santa Cruz, CA. This facility also stores skulls and baculums of deceased sea otters (collected at the time of necropsy).

Whisker/vibrissae samples will be sent to the Newsome Lab (Seth Newsome, co-investigator) at the University of New Mexico for storage and stable isotope analysis.

Hair and buccal swabs will be transferred to the lab of Dr. Holly Ernest at the University of California, Davis, for genetic analysis and storage.

Serum and nasal swabs will be stored at the Monterey Bay Aquarium but will eventually be sent to Tracey Goldstein at the University of California, Davis, for a viral study.

Adipose tissue samples will initially be stored at the Monterey Bay Aquarium but will eventually transferred to Dr. Kathy Ralls at the Smithsonian Institute for storage and fatty acid analysis.

Note that with the exception of Idexx Labs (for analysis of blood samples), the Ernest and Goldstein Labs at UCD (genetics analysis of fur and buccal swabs; viral study), and Kathy Ralls/Smithsonian (adipose tissue for fatty acid analysis) the all personnel and institutions collecting, analyzing, or storing samples are listed as co-investigators on this permit.

15. **Would near-term pregnant females be implanted with VHF tags? USGS's recent permit application #067925 on northern sea otters explicitly stated that near-term pregnant females would not have instruments implanted due to potential risk of post-surgical dehiscence (Q20e).**

Consistent with the previous version of our permit, we are not requesting to implant near-term pregnant females due to the risk of post-surgical dehiscence. Additionally, we plan to stick with the language in our most recent permit amendment that states that "the decision of whether or not to perform surgery on any sea otter will be made by the attending veterinary surgeon, and that this decision should be informed by the state of pregnancy (with no near-term surgeries) as well as the overall body condition of the animal and the surgical procedure under consideration."

16. **Since you state in response to Q20gi that vessel surveys may be conducted, potential disturbance of otters from vessel surveys may occur and takes are thus needed. Please respond accordingly to Q20bi-v.**

    In general, we do not expect to disturb sea otters during boat-based surveys. Unlike all the other boats on the water, the point of vessel-based surveys is to locate sea otters from a distance, and not disturb them. "Blowing out" a sea otter group would negatively impact our ability to obtain an accurate count. Since we stay well away from the otters and use binoculars, the likelihood of disturbance is very low, and is in fact, much lower than that of any other recreational or working boat on the water.

    If a specific take number is is required for all vessel surveys regardless of potential for disturbance, we propose that no more than 25 sea otters would be disturbed during any individual vessel-based survey. We typically do one vessel-based survey a year, so 25 takes per year for vessel-based surveys seems appropriate. Certain projects may have logistical constraints (e.g. limit shore access) that require more frequent vessel-based surveys to locate study animals, but at this time, we don't have any work that meets these criteria.

17. **Please briefly describe the methods used capture and restrain an otter and specify what measures would be implemented to ensure that individual otters are not recaptured unnecessarily (Q20d).**

    Capture methods are described in detail in the permit application (Q10). A brief summary follows:

    <u>Diver Operated Wilson Trap</u>

    Most sea otter captures will be conducted by diver-operated Wilson Trap. This method has been used for many decades, and is not only the most successful capture method, but is the safest method of capture for the otters. Divers are deployed from a boat from far away (typically 300-500m from the target otter(s)). Divers navigate a course to the target otter(s) underwater and are undetected the entire way. Oxygen rebreathers, which don't emit exhaust bubbles, are used to decrease the likelihood of detection. A diver-propulsion vehicle (or underwater scooter) is used to push the trap through the water. Once the divers arrive at the target otter(s) they quickly ascend from underneath the otter(s) and scoop them up in the Wilson Trap. A purse string is pulled, closing the mouth of the trap. Within a minute or two, the boat arrives to pick up the otters and divers. The otters are transferred from the Wilson Trap to a specially designed "otter box" on board the boat. The boat transports the otters to the veterinary facility (back deck of Monterey Aquarium, shore/beach/dock transfer for mobile vet labs, or transfer to larger vessel if vet procedures are being done aboard a large vessel). Prior to transferring the otter from boat to vet facility, the otter is "soaked" (partially submerged while still in the box) alongside the boat for at least 10 minutes. This allows the otter to thermoregulate in seawater, and also rinses the box of any feces or other debris, before going into the vet facility. Once in the vet facility, otters are manually restrained while in the otter box using a "bite bag" (duffle bag with tough exterior and soft filling). The bite bag blocks the otter's head while the veterinarian injects the sedative.

Diver-operated Wilson Traps are highly selective since the divers choose which otter they catch. This means that a specific sea otter (or pair of sea otters) can be targeted while resting in a group of 20, with very little chance of catching an unintended otter. Divers work in teams of two and each diver has a Wilson Trap. When the target otter is resting by itself, one diver will make an attempt to catch that otter. When the target otter is resting with two or more otters, both divers will make attempts to catch an otter, and in most cases, two otters will be captured simultaneously. By catching two otters at a time the likelihood of capturing out primary target otter is increased. The second otter captured can be considered a "secondary target" and how that otter is handled depends on the objective of the capture event and overall project.

There are two main types of capture events that differ slightly in how otters are handled:

1. Initial Captures: occur at the start of a project and most otters encountered can be considered to be potential targets for capture. The goal is to capture enough sea otters to meet our sample size requirements for the given study (usually 20-30 otters initially). During initial captures, if two otters are caught simultaneously both otters are equally valuable (co-primary targets) and typically both are brought to the veterinary facility for tagging and instrumentation.

2. Recaptures: are capture events where the primary targets are sea otters that have been previously captured and tagged. The goal of recaptures is to replace lost flipper tags and/or retrieve data via TDR explant. If the primary re-capture target is resting will other otters, we will attempt to catch two otters simultaneously, in order to increase our chances of successfully capturing the intended recapture target. How the second otter is handled depends on a variety of considerations. Typically, the second otter will also go into the vet for bio-sampling and flipper tagging, depending on the objectives of the study. The second otter may also get instrumented, if one of the goals of the capture event is to increase the sample size of our study. In some cases, the secondary otter may be released immediately after capture and would have only been restrained in the trap for seconds to minutes. Scenarios that would result in an immediate release of the secondary animal would be: (1) capture of mom without pup, (2) capture of pup without mom, (3) accidental re-capture of otter that had already been captured as part of the current capture event or (4) if there are too many otters in the vet queue. In the case of scenario 4, if the veterinarian tells us that

the wait time in the queue for the secondary otter will exceed the allowed processing time in this permit, we will immediately release the secondary otter.

Tangle Nets

When using tangle nets, it is difficult to target or avoid specific otters. This is one of the many reasons we use tangle nets only when dive captures are not possible. The restraint and handling of the otter is similar to the above description once the boat arrives at the tangle net. A bite bag is used to protect otter handlers while the otter is untangled from the net. Once in the otter box the rest of the procedures are the same.

Dip Nets

Dip netting is also highly selective since dip netters can target an individual otter. A non-target otter can also be immediately released from the dip net. Handling and restraint are the same as described above.

Please refer to the original application response for more details about capture methods.

18. From where on the body will blood be drawn? (Q20fv)

Blood samples are typically collected from the left or right common jugular vein. There may be rare occasions when smaller samples for blood gas determination (as part of anesthetic monitoring or emergency care) may be collected from the left or right popliteal vein (behind the knee joint). The latter site is used when it is unsafe or a violation of surgical etiquette to use the jugular vein.

19. How will the various samples be preserved? (Q20fxiii)?

Blood	smear	methanol fixed & dry storage
	Serum/plasma	frozen, -80 F
Swabs	project dependent	Dry, refrigerated, or frozen
Saliva	project dependent	Refrigerated, frozen
Feces	project dependent	Refrigerated, frozen, collection medium
Milk		Refrigerated, frozen
Urine		Refrigerated, frozen
Adipose tissue		Formalin fixed, frozen

Ext path	Formalin fixed, refrigerated, frozen
Liver bx	Formalin fixed, frozen
Premolar tooth	Dry storage, coin envelope

[Note: the anatomists call this tooth the second upper premolar, there isn't PM1]

Vibrissae	Dry storage, coin envelope
Baculum	Frozen
Tooth	Envelope; slides once processed
Skull	Frozen
Fur	Dry, coin envelope

20. **How will you approach otters during vessel surveys and will you distinguish between otters that are resting versus active (e.g., swimming, traveling)? What mitigation measures will be implemented if a reaction is noted by an otter in response to vessel presence? Will you approach a hauled out otter during ground surveys? (Q20gi)**

    Otters are not "approached" during vessel surveys. The vessel follows a course that roughly tracks the coastline but remains offshore. Surveyors scan with binoculars while the vessel is underway at medium speed (usually 10 knots or less). In general, the boat does not approach otters or groups of otters. If otters are in the path of the boat, the boat will alter its course to avoid disturbing the otters. Our observers are trained to notice early signs of disturbance (otters looking around, periscoping, etc.) and if these behaviors are observed, the boat will take corrective action, which typically involves increasing the distance between the vessel and the otters in question. Hauled out otters will not be approached during ground surveys. Ground surveyors are typically on cliffs or blufftops elevated above the intertidal. Elevation is necessary for better viewing during surveys and also prevents the surveyor from having a close encounter with hauled out otters or other marine mammals. In areas where obtaining elevation isn't possible the surveyors count from a distance that is set back from the intertidal and avoid approaching hauled out sea otters.

21. **Since takes of otters are needed for vessel surveys and possibly ground surveys if you plan on approaching hauled out otters, please specify whether 100 m would be the absolute minimum approach distance to an otter either on foot or by vessel. If you plan on using a different minimum approach distance, please explicitly state what that distance will be to resting otters (Q20gii).**

Takes are not needed for ground surveys. We will not be approaching or disturbing otters during ground surveys.

100m approach distance for vessel surveys is reasonable, but as always, we will modify our behavior at any distance that may appear to be disturbing the otters.

22. **Please confirm if the following statement is accurate. If not, please provide clarification (your application table doesn't indicate such, but other application information does).**
    - **Pups less than 11 lbs will be avoided for all sampling, sedation and instrumentation procedures, pups less than 20 lbs will be avoided for instrumentation, and near-term pregnant females will be avoided for instrumentation.**

This information is accurate. Pups of less than 11 lbs will not be tagged. In general, pups less than 11 lbs will not be sampled or sedated either, unless there is medical indication to do so. Pups of less than 20 lbs will not be instrumented. Near-term pregnant females will not be instrumented, and the ultimate decision to instrument any sea otter will be made by the attending veterinarian.

23. **How pregnant female will be deemed near-term if you plan on excluding them (e.g., with ossified fetus skull the size of a lemon)?**

The attending veterinarian will base her/his decision on state of pregnancy on a number of factors: 1) Body weight and length of the female, 2) abdominal palpation with a firm swelling whose size, shape, and firmness is consistent with ossified fetal skull, 3) the size, prominence, and milk presence/absence in the teats, 4) Auscultable fetal heartbeat, 5) if uncertain, abdominal radiography or ultrasound, if available.

24. **Why do you plan on anesthetizing/flipper tagging/sampling only half of the animals you expect to capture? Are you accounting for incidental captures or captures of pups less than 11 lbs? Please clarify.**

Yes, we are accounting for incidental captures and captures of pups less than 11 lbs. We are also providing a cushion to account for near-term pregnant females, geriatric animals, or any sea otter captured that the veterinarian deems to be a poor candidate for surgery or sampling.

25. **It is not clear how 1,250 was determined to be the total number of non-target otters harassed by captures. Please provide the justification for this number in the application.**

This is our best estimate and was calculated based on an approximate average group size of 1-3 sea otters in California. This estimate assumes each capture attempt was executed in a situation where the target otter was resting in a group of 3 total otters (the high end of the average group size range). In this scenario, if the entire group of 3 is disturbed or harassed, 1 (the target otter) would be counted as a "take" while the other 2 individuals would be incidentally harassed. So for each take, we are accounting for approximately 2 incidental harassments based on a group size of 3. Since average group size ranges from 1-3 individuals, incidental harassment is likely to be lower than our estimate. Extrapolated over the maximum number of takes we are requesting for this permit (600), we arrive at 1,200 possible cases of incidental harassment. We requested 1,250 in order to have a little extra cushion to help account for any unforeseen future changes in sea otter group size/distribution.

26. On your application table, please indicate the number of otters that may be disturbed by vessel or ground surveys in a year.

We believe this question was already asked in question #17, where we propose that no more than 25 sea otters will be disturbed by vessel-surveys per year. There is no possibility of disturbance via ground/shore surveys.

27. How would you ensure that a female and her pup are not separated during vessel surveys? (Q22)

This is not an issue when performing vessel surveys for sea otters. Females typically separate from pups when faced with a major, acute trauma (e.g. a predation event or boat running at high speed directly through an otter raft). Even in cases of major trauma or disturbance, pup separation is usually temporary (seconds to minutes) and the pair reunites immediately after the disturbance event has concluded. In decades of vessel-based sea otter surveys no one associated with our permit has ever seen a female and pup become separated due to research/survey vessel activity. In the case of very small pups, females take them everywhere they go. In the case of large pups, if the female doesn't take the pup with it, the pup is more than capable of keeping up with its mother. However, during vessel surveys we maintain an appropriate distance from otters with the goal of avoiding even low-level disturbance. Such low-level disturbance does not result in mother-pup separation.

28. As mentioned previously, please also explicitly state the minimum age/size of a pup that could be sedated and sampled (Q22-23).

We will not be sedating and sampling sea otters weighing less than 11 lbs, unless there is a medical indication to do so. Such an indication may include anomalies such as pre-existing injuries, fishing gear entwinement, oral foreign body.

29. As mentioned previously, please clarify whether near-term pregnant females could be instrumented if captured and how such a female would be deemed near-term (Q23).

Near-term females will not be instrumented if captured. The state of pregnancy (and whether the female is near-term) is determined by the attending veterinarian based on a number of factors: 1) Body weight and length of the female, 2) abdominal palpation with a firm swelling whose size, shape, and firmness is consistent with ossified fetal skull, 3) the size, prominence, and milk presence/absence in the teats, 4) Auscultable fetal heartbeat, 5) if uncertain, abdominal radiography or ultrasound, if available.

The ultimate decision on whether or not to implant any sea otter (pregnant or not) will be made by the attending veterinarian.

30. How will you minimize impacts to non-target individuals during tangle net activities, including both incidental net captures and incidental harassment during net tending? (Q24)

To start, we would like to reiterate that tangle nets are rarely used in California, and the only time we would ever use them is if dive captures are not possible. So potential impacts of tangle nets are already minimized by virtue of not using them most of the time. Should tangle nets need to be deployed, we will take all reasonable measures to minimize the disturbance and capture of non-target individuals. When tangle nets are deployed, they are most often used for initial captures and less often for recaptures. They are a poor choice for target animal recaptures since they are not very selective. When we are performing initial captures on a project (the first capture and tagging of individual otters) very few otters would be considered non-target individuals. In this case, most of the otters that swim into the net are possible target individuals.

If we are faced with a situation where large numbers of non-target sea otters are present in the area, we can minimize the potential for capture of non-targets by not deploying nets in these areas. We can also have the tender boat closer to the net, and ready to discourage non-target otters from swimming into the net (this could constitute a vessel-related harassment, but in our opinion, is an acceptable trade-off to avoid a harassment via net entanglement). Our shore observers can help greatly with this, since they have a better vantage point and can provide instructions to the boat. If non-target otters are caught in the net, they will be treated the same as target otters in that the tender boat would respond rapidly and disentangle (or cut out) the non-target otter as fast as possible. Rather than being placed in an otter box, the non-target otter would simply be immediately released. During boat tending, sea otter harassment is minimized using our normal boating practices which starts with maintaining an appropriate distance from otters. The boat may also shut off its motor (to minimize sound and smell), and will either drift offshore where they are unlikely to encounter otters or anchor/tie-off in a kelp bed (without nearby otters) and remain still and quiet, which are both effective measures at reducing vessel disturbance of sea otters.

31. Please state whether a necropsy would be conducted on an otter in the event of a death (Q27).

Yes, any known mortality where the carcass can be recovered will be subject to a complete necropsy. Our partners at the California Department of Fish & Wildlife's Marine Wildlife Veterinary Care and Research Center, under the supervision of one of the world's leading sea otter pathologists, Dr. Melissa Miller, would perform the necropsy. This procedure is consistent with every study animal mortality (with carcass recovery) under our permit for the past several decades. Our tagging studies have many goals, but chief among them is assessing survival and mortality, which cannot be done properly without detailed necropsies.

32. It is unclear whether the source of the specimens could include animals killed incidental to legal commercial fishing operations. Please provide clarification.

No, we are not requesting permission to sample dead sea otters killed in commercial fishing operations. This permit is for the capture and sampling of live wild sea otters and for the recovery of beach-cast sea otter carcasses.

Literature Cited

Tinker, M.T., Tomoleoni, J.A., Weitzman, B.P., Staedler, M., Jessup, D., Murray, M.J., Miller, M., Burgess, T., Bowen, L., Miles, A.K., Thometz, N., Tarjan, L., Golson, E., Batac, F., Dodd, E., Berberich, E., Kunz, J., Bentall, G., Fujii, J., Nicholson, T., Newsome, S., Melli, A., LaRoche, N., MacCormick, H., Johnson, A., Henkel, L., Kreuder-Johnson, C., and Conrad, P., 2019, Southern sea otter (Enhydra lutris nereis) population biology at Big Sur and Monterey, California --Investigating the consequences of resource abundance and anthropogenic stressors for sea otter recovery: U.S. Geological Survey Open-File Report 2019 -1022, 225 p., https://doi.org/10.3133/ofr20191022.

Re: MMPA application # 672624

Tomoleoni, Joseph A <jtomoleoni@usgs.gov>
Fri 6/12/2020 2:56 PM
To: Vargas, Darcy <darcy_vargas@fws.gov>
Cc: Yee, Julie L <julie_yee@usgs.gov>

2 attachments (2 MB)
Holly_Ernest_CV_11June2020.pdf; HollyErnest_SeaOtterResearchNarative_11Jun2020.pdf;

Hi Darcy,

Great! I've attached a CV and narrative for Holly Ernest.

Please let me know if you have any questions or need any additional info.

Best,

Joe

Joe Tomoleoni
Biologist
Dive Safety Officer (Southwest Region)
USGS - Western Ecological Research Center
2885 Mission St., Santa Cruz, CA 95060
O: 831.460.7447 C: 831.254.9750
jtomoleoni@usgs.gov

From: Vargas, Darcy <darcy_vargas@fws.gov>
Sent: Wednesday, June 10, 2020 9:31 AM
To: Tomoleoni, Joseph A <jtomoleoni@usgs.gov>
Cc: Yee, Julie L <julie_yee@usgs.gov>
Subject: Re: MMPA application # 672624

Hi Joe,

You got it. We only need a copy of her CV/resume and a short explanation as to what parts of your permit approvals she will be participating in.

Kind Regards,

Darcy Vargas
Biologist
US Fish and Wildlife Service
MS: IA
5275 Leesburg Pike
Falls Church, VA 22041-3803
www.fws.gov

UNIVERSITY OF WYOMING

Department of Veterinary Sciences
University of Wyoming

WILDLIFE GENOMICS & DISEASE ECOLOGY

June 11, 2020

RE: Narrative describing Sea Otter Research of the Ernest Wildlife Genomics and Disease Ecology Lab

Dear Joseph Tomoleoni and USGS,
Thank you for requesting a brief narrative about my the sea otter research of my lab. Our current work involves applications of DNA data to investigate and test associations between disease outcomes and genetics. I outline some of the ideas and directions my lab is taking in the following paragraphs.

To set the foundation for this work, our published work to date involved developing genetic tools specific to southern sea otters (Lam, et al. 2016); then applying those genetic tools to determine that southern sea otters had very low genetic diversity of southern sea otters and that the low level stayed static across the 15 years studied (Gagne et al. 2018). We collaborated with K. Ralls and others on a paper to test whether tool use in sea otters was associated with genetic metrics and relatedness (it was not shown to be; Ralls et al. 2017).

Our next focus now is to use 1) our existing microsatellite DNA data set (Nicole Carter's MS project) and generate whole genome data to test whether 1) certain disease outcomes that reduce otter fitness follow family lineages; and 2) certain pathogens and factors causing mortality are associated with host genomic factors (including specific gene variants promoting higher susceptibility).

Summary abstract for our current efforts:
Federally listed threatened Southern Sea Otters ("otters") along the California coast have death rates that impede population recovery. Pathogens associated with illness and death have been identified (including brain diseases caused by protozoal parasites, poisoning by marine biotoxins, and inflammation of the abdominal cavity caused by thorny-headed worms), as have fatal syndromes with unknown causes including end-lactation syndrome and a dilated heart syndrome. Development of management interventions require knowing *why and how* otters become sick and die from these causes. Low genetic diversity and a small effective population size of this otter population indicate genetic components could be contributing to declining otter population health. Genetic factors are correlated with cardiomyopathy and cerebral toxoplasmosis in humans and other species. Genomic studies are needed to determine how pathogens are associated with family lineages and disease susceptibility. This research aims to answer the important genetic susceptibility component of the Southern Sea Otter decline puzzle.

<u>Published literature involving work from my lab:</u>

Roderick B Gagne, M. Timothy Tinker, Katherine Ralls, L. Max Tarjan, Melissa A. Miller, Shawn Larson, Holly B. Ernest. 2018. **Demographic and genetic data redefine measures of population recovery for a keystone species, Southern Sea Otter**. *Evolutionary Applications*. Collaboration with the USGS, Calif. Dept of Fish and Wildlife Marine Wildlife Care and Research Center, UC Santa Cruz, and the Seattle Aquarium.

Katherine Ralls, Nancy Rotzel McInerney, Roderick Bashore Gagne, Holly B. Ernest, M. Tim Tinker, Jessica Fujii, Jesus Maldonado. **Mitogenomes and relatedness do not predict frequency of tool use by sea otters.** 2017. *Biology Letters*. Collaboration with the Smithsonian Institution, USGS, and UC Santa Cruz.

Lam L, RB Gagne, HB Ernest. 2016. Sea otter genetic markers developed. *Conservation Genetics Resources.* 8:43–81. **Development of 24 polymorphic microsatellite loci for the threatened Southern (California) sea otter (*Enhydra lutris nereis*)**

BOOK CHAPTER:

Larson S, K Ralls, **H Ernest. Sea Otter Conservation Genetics.** 2015. Chapter 5 in Sea Otter Conservation. Edited by Shawn Larson, James Bodkin, Glenn VanBlaricom. Academic Press/Elsevier.

Thank you,

Sincerely, Holly Ernest

Attachments - CV

Holly Ernest

Holly Ernest DVM, PhD
Professor, Wildlife Genomics and Disease Ecology
Excellence Chair in Disease Ecology
Department of Veterinary Sciences,
University of Wyoming
http://www.wildlifegenetichealth.org/
Holly.Ernest@uwyo.edu | 307-766-6605

Curriculum Vitae

Holly Ernest DVM, MS, PhD

Professor of Wildlife Genomics and Disease Ecology
Wyoming Excellence Chair in Disease Ecology
Fulbright Scholar 2021
Certified Senior Ecologist, Ecological Society of America
University of Wyoming, Laramie

- ***Researching** population ecology, genetics, and genomics for disease ecology;*
- ***Providing data and translating complex science** in an understandable way for improved wildlife management, conservation and population health*
- ***Educating** students, scientists, and wildlife health & conservation practitioners for futures in landscape-level research and action to benefit natural system conservation*

ADDRESS

Wildlife Genomics & Disease Ecology Lab
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http://www.WildlifeGeneticHealth.org/

Holly Ernest is a wildlife biologist, disease ecologist, research veterinarian, and professor who employs research tools of genomics, pathogen biology, and ecological sciences to answer questions of wildlife conservation and management importance. Dr. Ernest's focus is applied research on questions and problems for wildlife health in North America with special focus on the Rocky Mountain West.

She leads a program and lab that includes undergraduate, graduate, and post-doctoral training, mentoring and education, as well as service and outreach to the public. Holly joined UWyo faculty following a career (2002-2014) as a professor of Wildlife Genetics and Population Health at the University of California, Davis (and earning Emeritus Professor at UC Davis). Her UWyo team examines population ecology, health, diseases, and genetic diversity of species ranging from bighorn sheep, deer, elk, pronghorn, mountain lions, black bears, and otters to raptors and hummingbirds. Disease ecology studies include viruses, bacteria, protozoa, and helminth pathogens.

Dr. Ernest's team collaborates with >100 people from a range of university, agency, and stakeholder groups who aim to further research and improve wildlife population health in the Rocky Mountain West, Wyoming, California, and beyond. Dr. Ernest also consults for state and federal agencies and serves on the US federal National Institute of Standards and Technology panel for wildlife forensic genetics.

EDUCATION

Ph.D. in Ecology, specialization, wildlife health, population ecology, & genetics: University of California, Davis Graduate Group in Ecology. 2001**.**
Doctor of Veterinary Medicine, cum laude, Ohio State University, 1986.
M.S. Veterinary Physiology and Pharmacology, Ohio State University, 1982.
B.S., Biology, Cornell University, 1980.

CERTIFICATIONS and HONORS

- **Fulbright Scholar,** Wildlife Health, Genomics, and Disease Ecology at the Canada/USA interface. University of British Columbia. 2021
- **Sabbatical and Visiting Professor Status Awarded for Aug 2020-July 2021.** Wildlife Health, Genomics, and Disease Ecology at the Canada/USA interface. University of British Columbia. 2021
- **Certified Senior Ecologist, Ecological Society of America.** June 2019-present.
- **Federally permitted hummingbird bander**. 2009-present. Hummingbird capture, sampling, and banding in Arizona, Colorado, and California. Awarded Master Bander certificate by USGS (Bird Banding Lab, US Geological Survey) in 2011; valid through 2023.

POSITIONS

2014 Sep- to present	**Professor and Wyoming Excellence (endowed) Chair in Disease Ecology** **Lead Investigator, Wildlife Genomics and Disease Ecology Lab**, Department of Veterinary Sciences and Program in Ecology, University of Wyoming, Laramie Faculty Affiliate in the Haub School of the Environment and Natural Resources. Lab member group of undergraduate interns, graduate students, postdoctoral researchers, and research scientist/lab manager.
2014 Sep- to present	**Professor emeritus,** Wildlife Genetics, Genomics, and Population Health, Dept. of Population Health and Reproduction, Wildlife Health Center, and Veterinary Genetics Laboratory, UC Davis School of Veterinary Medicine.
2014 Jul-Sep	**Professor in Residence,** Wildlife Genetics, Genomics, and Population Health, Dept. of Population Health and Reproduction, UC Davis School of Veterinary Medicine
2010-2014	**Associate Professor in Residence**, Wildlife Genetics, Genomics, and Population Health, Dept. of Population Health and Reproduction, UC Davis School of Veterinary Medicine
2005-2010	**Assistant Professor in Residence**, Wildlife Genetics and Population Health Dept. of Population Health and Reproduction, UC Davis School of Veterinary Medicine
2002-present	**Laboratory Senior Investigator,** Wildlife Ecology Unit, Veterinary Genetics Laboratory (VGL), UC Davis. Founded the unit.
2002-2005	Associate Veterinarian, then **Assistant Research Geneticist** (title allowed major professor status for graduate students), VGL; founded Wildlife Ecology Unit 2002. Wildlife Genetics, Genomics, and Population Health lab has enjoyed productive research, teaching, and service success for over 10 years.
2002-2003	**Director of Forensics Unit**, VGL. Following 2003 directed 100% effort to Wildlife & Ecology Unit by my choice.
1999-2001	**Associate Wildlife Veterinarian**, Wildlife Health Center, UC Davis School of Veterinary Medicine.
1997-1999	**Academic Fellow & Adjunct Instructor**, UC Davis Department of Veterinary Pathology, Microbiology, and Immunology. Work with UCD first and second year vet students and courses in bacteriology, virology, immunology, parasitology courses, as well as UC Davis Wildlife Health Center courses in wildlife health and

restraint.

1997-1999 **PhD student in Ecology with fellowships in Wildlife Health and Ecology**

1993 Started PhD training at UC Davis Graduate Group in Ecology to transition career focus to Wildlife Ecology and Population Health. Special focus on wildlife population genetics.

1987-1993 **Clinical Veterinarian and Veterinary Hospital Owner/Manager**. Founded new veterinary hospital in 1987 and managed through 1993. Sold veterinary practice to start new career in wildlife biology & population genetics through Ecology PhD at UCD.

1986-1987 Employed Veterinarian, Medicine and Surgery, Internship. Oradell Animal Hospital, NJ.

Pre-1986 Undergrad, MS, and DVM student.

ACTIVE RESEARCH

Wildlife Genomics and Disease Ecology at large landscape scales: Answering questions about interactions of animals, rapidly changing landscapes, genetic diversity, and disease dynamics. *Wyoming's ungulates (pronghorn, mule deer, bighorn sheep, elk), Chronic Wasting Disease research in deer and elk; sea otter genetics for relatedness and genetic diversity, disease ecology, and genomics; Hummingbird field ecology, blood parasite disease ecology, and population genomics; Great Gray Owl population genomics; Mountain lion population genomics; black bear non-invasive molecular mark-recapture; Bioinformatics; Disease gene sequencing.*

PUBLICATIONS

Peer-reviewed journals include: Biology Letters, *Molecular Ecology, Biological Journal of the Linnaean Society, Evolutionary Applications, BMC Evolutionary Biology, Molecular Phylogenetics and Evolution, Conservation Genetics, PlosOne, Journal of Mammalogy, The Auk, Journal of Ornithology, Condor, Journal of Wildlife Diseases*, and others.

Updated publication list with links to pdfs: http://www.wildlifegenetichealth.org/publications/

*Denotes my role as senior author/primary mentor of first author; corresponding author

Published on BioRxiv or In journal review/revision:

*Braden Godwin, Melanie LaCava, Beth Mendelsohn, Roderick B. Gagne, Kyle D. Gustafson, Sierra M. Love Stowell, Andrew Engilis Jr., Lisa A. Tell, Holly B. Ernest. In journal review. **Novel hybrid finds a peri-urban niche: Allen's Hummingbirds in southern California.** Collaboration with UC Davis, Colorado State University, and others.

*Roderick B. Gagne, Daryl R. Trumbo, Melanie E.F. LaCava, Patricia E. Salerno, Christopher P. Kozakiewicz, T. Winston Vickers, Seth P.D. Riley, Jeffrey A. Sikich, Walter M. Boyce, Kevin R. Crooks, Sue VandeWoude, W. Chris Funk, **Holly B. Ernest**. **Landscape characteristics associated with gene flow of a top carnivore vary by population and scale**. *In revision for journal.* Collaboration with Colorado State University, Calif. Dept. of Fish and Wildlife, National Park Service, UC Davis.

Nicholas M. Fountain-Jones, Simona Kraberger, Roderick Gagne, Daryl R. Trumbo, Patricia Salerno, W. Chris Funk, Kevin Crooks, Roman Biek, Mathew Alldredge, Ken Logan, Guy

Baele, Simon Dellicour, Holly B Ernest, Sue VandeWoude, Scott Carver, Meggan E. Craft. **Host relatedness and landscape connectivity shape pathogen spread in a large secretive carnivore.** bioRxiv 816009; doi: https://doi.org/10.1101/816009 and in journal revision.

Shawn Larson, Jim Bodkin, Katherine Ralls, Roderick B. Gagne, Lizabeth Bowen, Raphael Leblois, Tim Tinker, and **Holly Ernest. Recovery of genetic diversity in remnant and translocated sea otters, *Enhydra lutris*.** In internal review for *Marine Mammal Science.*

Dellinger, Justin; Gustafson, Kyle; Gammons, Daniel; **Ernest, Holly**; Torres, Steven, **"Minimum habitat thresholds required for umbrella species genetic diversity**. In journal review

Published, accepted, or in-press:

2020 to date (June 2020)

*Love Stowell SM, RB Gagne, Doug McWhirter, William Edwards, **HB Ernest.** 2020**, J. Wildlife Management. Bighorn sheep genetic structure in Wyoming reflects geography and management.** Broad collaboration among institutions and agencies including University of Wyoming including the Wyoming State Veterinary Laboratory, Wyoming Department of Game and Fish, Wyoming Wild Sheep Foundation, the national Wild Sheep Foundation, Colorado State University, Wyoming Cooperative Fish and Wildlife Research Unit, University of California Davis, and others.

*Melanie E F LaCava, Roderick B Gagne, Sierra M Love Stowell, Kyle D Gustafson, C Alex Buerkle, Lee Knox, **Holly B Ernest**. 2020. **Pronghorn population genomics show connectivity in the core of their range**. *Journal of Mammalogy*. Broad collaboration among institutions and agencies including University of Wyoming including the Wyoming State Veterinary Laboratory, Wyoming Department of Game and Fish, Colorado State University, Wyoming Cooperative Fish and Wildlife Research Unit, University of California Davis, and others; with funding from University of Wyoming, the Y Cross Ranch endowments, the IDeA fund, and Excellence Chair funds.

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Julie Smith, Rebecca Lewison, Megan Jennings, Seth Riley, Laurel Serieys, Shaelynn Sleater-Squires, Erin Boydston, Kevin Crooks, **Holly B. Ernest.** 2020. **Carnivore population structure across an urbanization gradient: A regional genetic analysis of bobcats in southern California**, *Landscape Ecology*.

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B Ernest, Kevin Crooks, Sue VandeWoude and W Chris Funk. 2019. **Urbanization impacts apex predator gene flow but not genetic diversity across an urban-rural divide**. Molecular Ecology https://onlinelibrary.wiley.com/doi/full/10.1111/mec.15261

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Emily E. Graves, Karen A. Jelks, Janet E. Foley, Michael S. Filigenzi, Robert H. Poppenga, **Holly B. Ernest**, Richard Melnicoe, Lisa A. Tell. 2019. **Analysis of insecticide exposure in California hummingbirds using liquid chromatography-mass spectrometry**. *Environmental Science and Pollution Research*. Collaboration with UC Davis and others.

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2017

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BOOK CHAPTERS

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Ernest HB, W.M. Boyce. 2000. **DNA Identification of mountain lions involved in livestock predation and public safety incidents**. Proceedings of the 19th Vertebrate Pest Conference. T. P. Salmon and A. C. Crabb, Eds. Published at the University of California, Davis. 290-294.

OTHER PUBLICATIONS AND REPORTS (INTERNET AND MAGAZINE)

*Denotes role as primary mentor of first author

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Ernest HB. 2005. Contingency Captive Breeding Plan for Sierra Nevada Bighorn Sheep. Written under California Department of Fish and Game contract of 1999-2001. *First* published *online* for federal Sierra Nevada Bighorn sheep Recovery Plan in 2005. Web site: http://www.vgl.ucdavis.edu/wildlife/sheep_plan.html

Ernest HB. 2002-2003. Lead forensic DNA scientist signing on forensic reports. Forensic genetic evidence case reports submitted to law enforcement agencies (25 cases) and private parties involved in civil law suits (20 cases). Casework presented from federal, state, and local law enforcement agencies as well as to the general public to the Forensic Unit of the Veterinary Genetics Laboratory.

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Ernest HB. DNA analysis for mountain lion conservation. Outdoor California. May-June. 61(3)16-19. Invited paper. 2000.

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NCBI GENBANK AND DRYAD GENOMIC SEQUENCE ACCESSIONS

The National Institutes of Health genetic sequence database, an annotated collection of DNA sequences. NCBI = National Center for Biotechnology Information.

2019	*DRYAD.* Mountain lion SNPs/RADseq data. Pending. In journal review
2019	*DRYAD.* Bighorn sheep nuclear genotypes, mtDNA seq. 2020. JWM
2019	*DRYAD.* Great Gray Owl SNPs/RADseq data. 2020. *Cons Genetics*
2018	DRYAD. Mountain lion genotypes. *Conservation Genetics.* **Gustafson et al.**
2017	DRYAD. Domestic Ferret genotypes. *Evolutionary Applications.* **Gustafson et al.**
2017	DRYAD. Puma genotypes. *Royal Soc Open Sci* **Gustafson et al.**
2015	Sea otter genomic sequences. Genbank. **Ernest HB.**
2014	DRYAD. Puma genotypes. PlosOne 2014. **Ernest HB. e**t al.
2013	Avian pox virus genomic sequences. L Godoy (PhD student), **Ernest HB.**
2012	Ferret genomic sequences. JX469575- JX469596. **Ernest HB,** MG Hawkins.
2008	11 Yellow-billed Magpie microsatellite-containing sequences. EF580121-EF580131. **Ernest HB**
2008	19 White-tailed deer mitochondrial control region DNA sequences. **Ernest HB.** EF644627-EF644645
2008	58 Swainson's Hawk DNA sequences. Hull JM and **Ernest, HB.** DQ988163, DQ985707-DQ985730 microsatellite-containing sequences EF568742-EF568773 mitochondrial DNA sequences.
2008	36 Great Gray Owl. DNA microsatellite-containing sequences. Hull JM and **Ernest, HB.** EU348568-EU348603.
2008	14 Red-shouldered Hawk mitochondrial control region DNA sequences. FJ376542-FJ376555
2008	3 Ferruginous Hawk mitochondrial control región DNA sequences. Hull JM and **Ernest, HB.** EF568749-EF568751.
2006	21 Puma DNA microsatellite-containing sequences. Kurushima and Ernest, HB. DQ660984-DQ661004.

RESEARCH FUNDED BY GRANTS, CONTRACTS AND OTHER FUNDING

Research in applied wildlife population genetics and disease ecology; landscape scales; Mammals and birds ranging from mountain lion, pronghorn, bighorn sheep, black bear, sea otter, hummingbirds, Yellow-billed Magpie, hawks, Great Gray Owl. Grant funding awarded to Ernest University of Wyoming Lab 2015-present totals ~[redacted] Grant funding awarded to Ernest UC Davis Lab prior to 2014 totaled ~[redacted]

Lab project page: http://www.wildlifegenetichealth.org/projects-research/

Role is principle investigator unless noted. Grants – Active/Recent at University of Wyoming

Fulbright Scholar Award to H. Ernest for Jan-July 2021. Transborder Wildlife Health, Genomics, and Disease Ecology, Canada-USA. Host Institution: University of British Columbia. [redacted]

Sabbatical Award (Flittie) to H. Ernest for Aug 2020-July 2021. Transborder Wildlife Health, Genomics, and Disease Ecology, Canada-USA. Host Institution: University of British

Columbia. [redacted]

Principal Investigator, **Genetics and non-invasive molecular mark-recapture for population estimation of black bears in California**. California Department of Fish and Wildlife. 2019-2022 (CDFW delayed contract signing to Apr 2020 so likely will re-budget). $[redacted]

Principal Investigator, **State-wide genetics and non-invasive molecular mark-recapture for population estimation of mountain lions in California**, California Department of Fish and Wildlife. 2015-2020. [redacted]

Principle Investigator, **Sagebrush ecosystem ungulates genomics and disease ecology**. US Fish and Wildlife Service (USFWS), US Bureau of Land Management (BLM), US Geological Survey (USGS). With PhD Candidate Melanie LaCava. 2019-2020. [redacted] grant.

Principal Investigator, **Landscape Disease Ecology - Mule Deer Population Genomics and CWD Genotyping in Wyoming,** Wyoming Governor's Big Game Grants 2017-2021. With PhD Candidate Melanie LaCava. [redacted]

Principal Investigator, **Bighorn sheep Population Genomics in Wyoming**, Wyoming Governor's Big Game Grants and Wyoming Wild Sheep Foundation. Research includes work of Postdoctoral Researcher, Dr. Sierra Love Stowell. 2015-2021.

Principal Investigator, with PhD Candidate Melanie LaCava. **Mule Deer CWD Genotype Study.** WGFD. 2017-present. [redacted]

Principal Mentor, for undergrad researcher Adrienne Mackenzie. **Landscape-scale Hummingbird Hemoparasite study.** (NASA-WY and INBRE funding)

Excellence Chair Awards to H. Ernest 2014-present.

P.I. and Mentor to students for their grant-funded research: NSF undergrad student REU-Erin Bentley, Grad Student Biodiversity grants (Hummingbird, Pronghorn Genomics), Bert and Meg Raynes Grants (Great Gray Owl and Hummingbird Genomics), Wyoming Wildlife Grant; Postdoc grants (Sierra Love Stowell: Cutthroat Trout Genomics and others)

Grants – UWyo Completed 2014 and prior

2016-2019 Principal Investigator, Genetics and non-invasive molecular mark-recapture for population estimation of black bears in California. California Department of Fish and Wildlife.

2014-2019 Co-Investigator, Impacts of Landscape Structure, Host Demography, and Management Interventions on Disease Dynamics of Mountain Lions. National Science Foundation Ecology and Evolution of Infectious Disease. Collaboration with Colorado State University, University of Minnesota, and University of Tasmania. PI = Dr. Sue VandeWoude. Grant to consortium of researchers: *Plus 2017 NSF REU (Research Experiences for Undergraduates) add on for Ernest undergrad intern, Erin Bentley's work on broader impacts component to develop K-12 video game illustrating and training disease dynamics for kids.*

2014-2017 Co-I. Mountain lion genetics and population dynamics in Southern California. SANDAG, consortium of counties.

2017-2018 Co- Investigator with Postdoctoral Researcher, Dr. Sierra Love Stowell,

Translocation genetics of Wyoming Bighorn sheep, National Wild Sheep Foundation. 2017-2018
2017-2019 Co-PI for postdoc Dr. Sierra Love Stowell. USFWS Cutthroat trout genomics.

Grants – Completed (UC Davis, and as PI, except where noted)
2014-2015 Principal Investigator, Foundation of Wyoming-based Hummingbird Health Research Program. Kelly Ornithological Research Fund.
2012-2015 Principal Investigator, Genetics for population monitoring of Black Bears in California's Coast Ranges, California Department of Fish and Wildlife.
2012-2015 Principal Investigator, Cost-Benefit Analysis for Monitoring Black Bear Populations. California Department of Fish and Wildlife. Included with figure above.
2012-2015 Co-Investigator, Genetics of Bighorn sheep throughout the desert southwest, The Nature Conservancy.
2013-2015 Co-Investigator, Genetics for territoriality, reproductive success and dispersal in southern sea otters, UC Santa Cruz / US Fish and Wildlife Service.
2012-2014 Principal Investigator, Hummingbird Health and Diseases in California, US Fish and Wildlife Service
2013-2014 Co-Investigator, Transborder California-Mexico landscape genetics of endangered Bighorn sheep. The Nature Conservancy.
2011-2014 Principal Investigator, Landscape Genetic Assessment of Arizona Desert Bighorn sheep, Arizona Dept. of Game and Fish.
2013-2014 Provost's Fellowship to mentored undergraduate student, hummingbird genetics for conservation: DNA sexing marker development.
2011-2013 Principal Investigator, Advancing diagnostics for hunter food safety: comparing the efficacy of PCR and serology tests for Trichinella in game meat, California Food and Animal Health.
2011-2013 Co-Investigator, Genetics of mountain lions in Santa Cruz Mountains, UC Santa Cruz.
2011-2014 Co-Investigator, Genetics of mountain lions in San Diego County, The Nature Conservancy.
2004-2014 Co- Investigator, Genetics of mountain lions in Santa Monica Mountains, National Park Service.
2012-2013 Principal Investigator, Mark-recapture genetics of Black Bears in Mammoth, CA region, Mono County - Collaboration with Utah State University.
2010-2011 Foundation of Davis Hummingbird Field Ecology Research Station. UC Academic Senate Faculty Grant.
2009-2011 Conservation Genetics of Hummingbirds: DNA Sequence Assessment toward Development of Nuclear DNA Single Nucleotide Polymorphism Markers. Western Hummingbird Project.
2007-2010 Yellow-billed Magpie Ecology and Population Genetics. California Department of Fish and Game/US Fish and Wildlife Service.
2007-2011 Genetic Assessment of Inbreeding for Cancer in Pet Ferrets. Center for Companion Animal Health.
2006-2011 Yellow-billed Magpie genetic research during West Nile virus outbreak. Audubon Society chapters.

2006-2011 California Sea Otter DNA marker development. Monterey Bay Aquarium.
2007-2008 Galapagos Hawk population genetic analysis. University of Missouri. (Co-PI, post-doctoral researcher J. Hull)
2007-2009 Yosemite Fund. USDA Forest Service and National Park Service. Great Gray Owl Population Genetics and Monitoring.
2007-2010 Yellow-billed Magpie genetics and ecology research. Private donations from individuals.
2006 California Sea Otter DNA marker development. California Department of Fish and Game.
2005-2006 West Nile Virus Antibody Prevalence among Native Raptors Migrating through the Marin Headlands. Graduate student Joshua Hull wrote grant. National Park Service.
2005-2008 State-wide population genetic analysis of wild pigs. California Department of Fish and Game.
2005-2008 Population genetic and kinship assessment of white-tailed deer infected with chronic wasting disease. USDA Animal Research Service. Income through genetic service recharge.
2004-2007 State-wide population genetic analysis of black bears. California Department of Fish and Game.
2004-2005 Swainson's Hawks Health Assessment: West Nile Virus Antibody Levels and Genetics; Great Gray Owls: Health Assessment, Antibody Levels and Genetics. Natural Resources Assessment Program of California Department of Fish Game and UCD Wildlife Health Center.
2004-2006 West Nile virus in Spotted Owls and Great Gray Owls: health assessment, antibody levels and genetics. Co-investigators: Keane (USFS), Ernest, Hull (PhD student), L.A. Tell (VM:M&E), & W. Reisen (SVM-CVEC). USDA Forest Service.
2003-2007 Comparative Genetic Diversity and Population Structure of Swainson's Hawk in the Central Valley of California. Swainson's Hawk Technical Advisory Committee (CA Dept of Water Resources)
2003-2005 West Nile Virus Antibody Levels in Swainson's Hawks. California Department of Fish and Game.
2002-2008 Genetic resource banking for *Puma concolor* (mountain lion), Bears, Wild pigs, Raptors, Corvids. UC Genetic Resources Conservation Program.

2002 - Start of academic permanent position
<u>2001 and prior – grants and contracts received while working on PhD in Ecology at UC Davis:</u>
1999-2001 Contingency captive breeding plan for endangered bighorn sheep, mountain lion genetic analysis, ecological and genetic consultation. California Department of Fish and Game contracts for Sierra Nevada Bighorn Sheep Recovery Program. Work as Associate Wildlife Veterinarian.
1999-2002 Statewide Population Genetic Analysis of Mountain Lions in Nevada. Nevada Division of Wildlife's Heritage Fund and the U.S. Fish and Wildlife Service.
1997-1998 DNA Identification of Mountain Lions Involved in Predation of Domestic Sheep and Bighorn Sheep. Department of Agriculture and Natural Resources (University of California and State of California). P.I. Dr. Walter Boyce; Co-PI Ernest (primary author of grant and conducted research) and others.

1997-1998	Mountain lion fecal DNA at Bighorn sheep kill sites: predator genetic identity. American Museum of Natural History - Theodore Roosevelt Memorial Fund.
1997	Mountain Lion Forensic DNA Study. Friends of the Intermountain Region, Siskiyou and Shasta Counties, CA.
1996-1997	Mountain Lion Forensic DNA Study. CDFG Wildlife Protection Division Wildlife Forensic Lab. In-kind donation of pipettes and lab materials.
1996-1997	Mountain Lion Research. Yosemite National Park - Yosemite Fund.
1994-1999	Mountain Lion Ecological Genetics. Co-PI with Walter Boyce. UC Genetic Resources Conservation Program. Mountain Lion Ecological Genetics.

INSTRUCTION – UNDERGRADUATE, GRADUATE AND VETERINARY (UWYO & UC DAVIS)

Teaching Interests: *Making disease ecology, wildlife population health, ecosystem health, One Health, and genomic sciences accessible and meaningful to students. Applications and theory of genomics and genetics for wildlife health, conservation, and management; population genetics, population genetic statistical analyses & software, wildlife disease ecology and epidemiology. Mentoring veterinary and pre-veterinary students.*

Course Instructor

2020-present	New graduate seminar course developed: **Ecology and Genomics of Disease**. University of Wyoming. Review and discuss recent journal papers. Two additional group learning term project segments; 1) "Coffee Break Disease Ecology" segment (chapter-by Chapter read book such as Hurst et al 2018; 2) segment for advanced credit with term projects.
2016-present	New graduate seminar course developed: **Conservation Genomics**. University of Wyoming. Review and discuss recent journal papers. Two additional group learning term project segments; 1) "Coffee Break Conservation Genomics" segment (chapter-by Chapter read population/conservation genetics book); 2) segment for advanced credit with term projects.
2016-present	New course developed: **Disease Ecology**. University of Wyoming. Teach yearly to undergraduate and graduate students. Includes computer lab for disease and risk assessment modeling. 2019 incorporating new R computational segment for S-I-R modeling.
2011-2014	**Co-Leader for School of Veterinary Medicine new curriculum in Population Health.** UC Davis School of Veterinary Medicine embarked on total curriculum revamp starting ~2008. I became involved in development of population health and ecosystem health material in 2009. Appointed co-leader to develop and deliver population health veterinary material to first and second year veterinary students. Developed new material, guided and coordinated faculty instructors on implementation, participated in teaching and problem-based, team-based, and case-based learning facilitation. One of main developers for the first core curriculum in One Health for UC Davis SVM vet student training
2007-2013	**Applied Ecological Genetics and Genomics for Wildlife Conservation,**

	Management, and Health (PHR 242 and ECL 242). Developed new course to introduce ecology students to applications of genomics and genetics. For graduate students, and advanced undergraduates.
2011, 2012, 2013	Facilitation teaching for problem-based learning in vet school new curriculum first year core foundations course.
2010, 2011	**Landscape Genetics with GIS.** Developed new graduate computer laboratory course to introduce PhD and MS students to genetic data analysis and informatics using geospatial and landscape genetics tools including add-ins to ArcGIS.
2004, 2007, 2008	**UCD graduate student seminar (ECL 290)**. Course leader. Data analysis and software for population genetics. 2008 sole instructor; 2004: Co-taught with Dr. Bernie May, UCD Dept. of Animal Science; 2008 Co-led with Dr. John Eadie (Wildlife and Fisheries Biology) and Dr. May. Resulted in online population genetics analysis guides.
2004, 2009	**Graduate student seminar (ECL 290)**: Molecular Genetic Markers in Ecology. 2009 sole instructor; 2004: Co-led course with Dr. Bernie May, UCD Dept. of Animal Science.

Invited Guest Lecturer – UC Davis courses

2015	Courses in Program in Ecology and Ecosystem and Rangeland Sciences, Univ. Wyoming.
2013 & 2014	One Health/Ecosystem Health (VME201) "Genetics and Genomics for Wildlife population health".
2012	Genetics and Genomics for wild bird conservation and population health. AVS 103 (Avian Science undergraduate course lecture). Dec 2012.
2012	Genetics toward conservation of California's Wildlife. ENH 150 Undergraduate conservation genetics course. Nov 2012.
2012	Molecular Epidemiology (graduate course EPI298) "Molecular Epidemiology for Wildlife Conservation" Spring 2012
2012	"Intrepid Research Explorers Seminar Series (Epidemiology graduate group EPI290): Disease ecology in California's wild birds and mammals: Striving for the great questions, research approaches, samples and data. Spring 2012
2011	Forensic Science Graduate Group Seminar: Wildlife Forensic Genetics Research.
2007, 2008, 2009	Veterinary Doctoring (VMD400) for 2nd and 3rd year vet students. Faculty guide for medical case scenarios.
2008-2012 annually	Ecosystem Health (VME201/VME401/VME298) "Genetics for Wildlife population health"
2009	Seminar in Epidemiology (VME290) "Linking wildlife genetics with population health: research on California's hummingbirds, magpies, and sea otters."
2008	Conservation Ecology (ECL208) "Genetic tools for Conservation Ecology"
2007	Changing Patterns of Vector-borne Infections (PHR214/ENT214) "Wildlife Vector-borne Diseases"
2007	Advanced Concepts in Epidemiologic Study Design (EPI207) "Genetics on

	the Wild Side: Opportunities & Challenges for Epidemiology"
2004-2007 annually	Veterinary Genetics (VMD 425). First year veterinary student core course. Lectures and discussion sections in population genetics, conservation genetics, wildlife genetics, and immunogenetics.
2003, 2005	Genetics and Society (SAS 20) Undergraduate course. "Wildlife Genetics"
2005	Complex Systems Behavior in Ecology (ECL200B). Core Ecology graduate course.
2004, 2005, 2006	"Genetic considerations for wildlife reproduction' in course: Reproduction of Nondomestic Animals (PHR 446C).
2003, 2005	"Genetics for Wildlife Health"; in "Cases in Genetics for Wildlife Health" VMD 418 Veterinary and Graduate Student course.
2005	Environmental Toxicology 20 for Forensic Science graduate students and E-tox undergraduates. "Wildlife Forensic Genetics"
2003	Forensic DNA analysis graduate course. "Wildlife Forensic Genetics"
1997-1999	Academic Fellow and instructor in veterinary core curriculum courses_(1st and 2nd year) in bacteriology, immunology, parasitology, virology, UC Davis; 2nd and 3rd year vet student course in wildlife restraint and disease field courses, senior veterinary student clinical sciences review course.
1994	Teaching Assistantship, UC Davis, Biological Science 1 B (Animal Ecology, Taxonomy, and Evolution). 1994.

Advanced training in teaching approaches and techniques, and leadership

2014	Hybrid course development course for faculty. January 2014.
2013	School of Veterinary Medicine Dean's Academic Council year-long training sessions in Academic Leadership. Selected by Dean's Academic Council.
2010-2012	Veterinary student education training for development and implementation of new curriculum in UC Davis School of Veterinary Medicine.
2009	Veterinary Doctoring teaching workshop.
2007-2008	Teaching Scholars program. UCD Medical School.
2007 and 2008	UCD Summer Institute in Teaching and Technology (SITT).

AFFILIATIONS AND SERVICE FOR UNIVERSITY OF WYOMING. 2014-PRESENT

UWyo Graduate Council Member, voted in, one of two representing College of Agriculture and Natural Resources. 2017-2020.

Program in Ecology, Graduate program in Veterinary Sciences, Wyoming Wildlife Livestock Health Center, Haub School Environment and Natural Resources and Biodiversity Institute

Chair, Program in Ecology Curriculum Committee, 2016-present

Graduate Program Coordinator, Department of Veterinary Sciences, 2017-present.

Serve on multiple MS and PhD graduate committees involving diversity wildlife disease and population genomics systems.

AFFILIATIONS AND SERVICE FOR UC DAVIS. THROUGH 2014

Graduate groups in Animal Biology, Avian Sciences, Ecology, Epidemiology, Forensic Science, Genetics, and Masters in Preventive Veterinary Medicine (MPVM). Major Professor, academic advising, mentorship and PhD qualifying examiner for over 100 M.S. and PhD graduate students. Invited member of Designated Emphasis Programs specialization for PhD students in Biology of Vector-borne Diseases and Organism-Environment Interaction.

2011-2014 Executive committees of MPVM, Epidemiology, and Ecology Graduate Groups (elected position); advising committee of Genetics Graduate Group.
2010-2012 Executive committee of Avian Science Graduate Group.
2002-2011 Chair of Genetics Graduate group Recruitment Committee; Executive committee membership in Forensic Science (at foundation of group) and Ecology Graduate Groups; Curriculum, Admissions and/or Awards committees of Ecology, Genetics and Preventive Veterinary Medicine Graduate Groups. Approx. 125 students advised since 2003 in various capacities (major professor, grad group adviser, STAR vet student mentor, etc.)

POST-DOCTORAL TRAINING, YEARS IN MY LAB (RESEARCHER'S CURRENT STATUS) – UC DAVIS

Benjamin Sacks 2002-2005 (Adjunct Professor, UC Davis)
Joshua Hull 2008-2009 (Branch Chief/Supervising Biologist, U.S. Fish and Wildlife Service; and Asst. Adjunct Professor at San Francisco State University and UC Davis) – current collaboration with my lab on wildlife research
Michael Buchalski 2013-2014 primary mentor; 2014-2015 co-mentored with Dr. Walter Boyce. Postdoc with Oregon State U/New Mexico State U. 2016; Wildlife Geneticist at California Dept of Fish and Wildlife, 2016-present. Current collaboration with my lab on wildlife research, including bighorn sheep.

POST-DOCTORAL TRAINING – U WYOMING

Postdocs below work/collaborate actively with lab projects and assisting graduate and undergraduate students
Erick Gagne PhD 2015-2017 (current position = postdoc, VandeWoude Virology Lab, CSU College of Veterinary Medicine and Biomedical Research)
Sierra Love Stowell PhD 2016-2018 (current position, Research Genomicist in Boulder, CO)
Kyle Gustafson PhD 2016-2018 (current position, Asst Professor of Biology and Genetics, Missouri Southern State University)

GRADUATE STUDENT TRAINING (RESEARCHER'S CURRENT STATUS) – U WYOMING

Melanie LaCava, PhD Candidate, 2015-present. Program in Ecology and Minor in Environment and Natural Resources. Graduation expected 2020. Wyoming Ungulate population genomics and Chronic Wasting Disease Ecology at large landscape levels. Graduation expected 2020.
Will Swain PhD Student, 2020-present. Program in Ecology. Wyoming Elk population genomics and Chronic Wasting Disease Ecology at large landscape levels.
Beth Mendelsohn, MS student, Fall 2016-Dec 2018 (Graduated 2018). Double Major: Veterinary Sciences and Environment and Natural Resources. Great Gray Owl population genomics at large landscape levels.
Nicole Carter, MS student, Fall 2018-May 2020. Double Major: Veterinary Sciences and

Environment and Natural Resources. Southern Sea Otter Genetic Relatedness and Disease Ecology. Graduated May 2020.

Braden Godwin, MS Candidate, 2015-Dec 2019. Double Major: Veterinary Sciences and Environment and Natural Resources. Hummingbird population genomics in California and Rocky Mountain landscapes. Graduated December 2019.

POST-GRADUATE RESEARCH SCIENTIST MENTORSHIP – U WYOMING

Laura Johnson, MS, Assistant Research Scientist, Lab Manager & Lead Lab Technician, Multiple genetics projects (Lead in Lab on Mountain lion, Bear; Assisting in lab on Sea otter, Mule Deer, Elk, Hummingbird, 2018-present.

Megan Dudenhoeffer, MS, Assistant Research Scientist, Assistant Technician, Assisting in lab on Mountain lion and Bear genetics projects, 2020-present.

Amelia Vazquez, MS, Assistant Research Scientist, Lab Manager, Mountain lion and Bear lab projects, 2016-2018.

Adrienne McKenzie, BS, Hummingbird Hemoparasite Project, 2020-present

Erin Bentley, BS, Ungulate lab work, 2018

GRADUATE STUDENT TRAINING – UC DAVIS

Graduated: 14 graduate students from my lab at UC Davis.

UNDERGRADUATE LABORATORY WILDLIFE GENETICS INTERNSHIP HOST – UW

2015-2018. Erin Bentley, Animal Science/Veterinary Science major, 2018. Now MS student in UWyo colleague's microbiology lab.

2017-present. Adrienne Mackenzie. Animal Science/Veterinary Sci major, BS expected 2020.

2018-May 2019. Marguerite Johnson. Wildlife Biology major, BS 2019. Now UWyo MS student

2018- May 2019. Emily Winward. Physiology major, BS 2019.

LABORATORY INTERNSHIP HOST – UC DAVIS

Wildlife Genetics Interns (veterinary students or undergraduates): 14 graduate students from my lab. 12 are now veterinarians; most of rest continued to graduate training.

UNDERGRADUATE STUDENT MENTORING

Mentored and provided laboratory and field ecology internships in Wildlife Health, Diseases, and Genetics to numerous undergraduate students since 2003 (nearly all proceeded to graduate or veterinary school).

HONORS AND AWARDS

2019	Offered an endowed professor chair at other university (wildlife genomics and disease ecology); accepted retention package at University of Wyoming.
2014	Excellence Chair in Disease Ecology. University of Wyoming
2013	Finalist for Associate Dean of Student Programs, UC Davis School of Veterinary Medicine. Demonstrated leadership abilities and potential.
2011-2023	Awarded Master Bird Bander Permit/Hummingbirds by USGS Bird Banding Lab (one of fewer than ~ 150 specifically for hummingbirds nationally, while >4000 permitted for other birds). Permit renewed through 2023 for states including

Wyoming, Colorado, Arizona, California, and Oregon

2007-2008 Selected for one-year "Teaching Scholars" certificate program for professors in UC Davis School of Medical and School of Veterinary Medicine. Training in teaching problem/case-based learning and techniques for adult learners.

1997-1999 Graduate Academic Fellowship: Pathology, Microbiology and Immunology in School of Veterinary Medicine. Two years.

1995-1996 Research Fellowship in Wildlife Health, UC Davis School of Veterinary Medicine.

1996-1997 Fellowship in Ecology, UC Davis, 1993-94 Two years.

1996-1997 Jastro-Shields Scholarship Award for Mountain Lion Ecological Genetics.

1996 Student research presentation award honorable mention, Wildlife Disease Association, Fairbanks, AK 1996

1986 Hill's Senior Veterinary Student Internal Medicine Award.

1986 Phi Zeta Veterinary Honor Society (top 10% of veterinary class)

1986 American Veterinary Medical Association Senior Veterinary Student Service Award (included service as SCAVMA President)

1985 Ohio State University College of Veterinary Medicine Junior Service Award

INVITED PRESENTATIONS – SEMINARS, WORKSHOPS

2017, 2018 Invited speaker for University of Wyoming's "Saturday-U" program to bring professors and their craft to the public around the state of Wyoming. Main focus was bighorn sheep.

2016 Invited speaker for University of Idaho Wildlife Seminar series. "Genomics of wildlife and their diseases: research views of a molecular ecologist/wildlife veterinarian". April 2016.

2016 Invited speaker for Laramie Audubon monthly talk: Hummingbird Health Program in Wyoming and Colorado.

2014 Invited to speak for Ecological Society of America annual conference, talk, "Ecology and impacts of vector-borne disease on native birds: California avian communities". Deferred to collaborator to present talk due to move to Wyoming: Lisa A. Tell (speaker) (UC Davis School of Veterinary Medicine, Holly B. Ernest, Sarah Bahan (vet student), Ravinder N.M. Sehgal (Dept. of Biology, San Francisco State University), Joshua M. Hull (Recovery Division Chief, Sacramento US Fish and Wildlife Office, and Dept. of Animal Science, UC Davis).

2014 Scheduled July 2014. For California Mountain Lion Researchers Workshop. "California's mountain lion landscape genetics: informing conservation and management. Holly B. Ernest (speaker), T. Winston Vickers (UCD Wildlife Health Center), Walter M. Boyce (UCD Wildlife Health Center), Seth P. D. Riley (National Park Service-Santa Monica Mountains National Recreation Area), Christopher C. Wilmers (Environmental Studies Division, UC Santa Cruz).

2013 Oct 2013 as invited speaker for The Wildlife Society annual Conference to lead-off the workshop in "Application of Molecular and Genetic Techniques to Wildlife Epidemiology".

2012 California Wildlife Connectivity Forum, UC Berkeley. Genetics for Landscape Connectivity. Dec 2012.

2012 Ernest H. Hummingbirds: Environmental sentinels, ecology and genetics. City of

	Davis Native Pollinator Talk Series. April 2012.
2010	Hummingbird Monitoring Network Workshop, Patagonia, Arizona. Updates on Hummingbird Conservation Genetics and Diseases of hummingbirds.
2009	Hummingbird Workshop, Cooper Ornithology Conference. Tucson, AZ. Two talks: 1) Genetic Tools for Hummingbird Conservation (solo talk); 2) Diseases and population health of hummingbirds: State of current knowledge and priorities for research (joint presentation with Dr. Lisa Tell.
2007	University of Minnesota. Genetics on the Wild Side: *Opportunities & Challenges in Wildlife Ecological Genetics. Additionally,* day of meetings to advise students and faculty on their ecological genetics projects; invited to speak at meeting of U Minnesota School of Vet Med's committee to organize a Ecosystem Health program. Minneapolis.
2006	The Wildlife Society, Sacramento-Shasta chapter. Chased by West Nile Virus: Yellow-billed Magpie. Sacramento.
2006	Wildlife and Aquatic Animal Medicine Symposium. Clinical and Epidemiologic Update on West Nile Virus. UC Davis. Joint Talk with Dr. Nancy Anderson. UCD.
2005	Genetic Monitoring Workshop, for California Department of Parks and Recreation and Genetic Resources Conservation Program. Audience: state and federal wildlife and environmental agency biologists and administrators. Genetic Monitoring of Wildlife: Mammals and Birds. Davis.
2004	International Society for Animal Genetics Conference Animal Forensic Genetics Workshop. Wildlife Forensic Genetics. Tokyo, Japan.
2004	US Department of Agriculture Wildlife Services Conference: Genetics for Wildlife Health. Training for USDA field personnel. Yosemite, CA.
2004	UC Davis Veterinary Medicine Population Health & Reproduction Seminar: Genomics for Wildlife Population Health.
2004	California Department of Health Sciences. Zoonotic Diseases Workshop. "Threatened & Endangered California Species potentially at risk for West Nile Virus". Sacramento.
2002 & 2003	Envirovet Summer Institute. White Oak Plantation, Florida. Seminar in Conservation Genetics, as part of the six week program for veterinary students, veterinarians, and wildlife biologists in terrestrial and aquatic wildlife and ecosystem health.
2003	Forensic DNA Course for Forensic Science Masters of Science curriculum. Animal Forensic DNA Analysis.
2002	California Association of Criminalists bay area meeting. Animal Forensic DNA analysis.

RESEARCH PRESENTATION ABSTRACTS

* Presenter (students, postdocs, research associates listed as speakers were mentored by H. Ernest). Since 2002

2019	H. Ernest. Presentation. "**Enhancing Wildlife Health and Conservation from Individual to Species. Research at the Wildlife Genomics and Disease Ecology** Lab, Univ. of Wyoming. ANGUS Bioinformatics Workshop, UC Davis. July

	1-13, 2019
2019	(Submitted) Shawn Larsen, Roderick Gagne, James Bodkin, Tim Tinker, Liz Bowen, **Holly Ernest,** Katherine Ralls, and Raphael Leblois. **Sea otter genetics update: Diversity, population structure and taxonomy.** World Marine Mammal Conference. Barcelona Spain. Dec 2019
2019	*Melanie LaCava, Sierra M. Love Stowell, Roderick B. Gagne, Holly B. Ernest. **Implications of marker type and species ecology on forensic use of genetic data:** STRs and SNPs in wild ungulates. June 2019. Society for Wildlife Forensic Science, Denver, CO.
2019	*L. Johnson (presenter) and H. Ernest. Presentation. **"Enhancing Wildlife Health and Conservation from Individual to Species for Forensic Applications.** June 2019. Society for Wildlife Forensic Science, Denver, CO.
2019	*Nicole H. Carter, Melissa A. Miller, Roderick B. Gagne, Berit Bangoura, Christine K. Johnson, Megan Moriarty, Tim Tinker, Jason Gigley, Holly B. Ernest. **Investigating the Relationship between Genetics and Disease Outcome in Necropsied Southern Sea Otters (*Enhydra Lutris Nereis*).** Biennial Sea Otter Workshop. Seattle. Mar 2019.
2019	*Adrienne Mackenzie, Brady Godwin, Berit Bangoura, Ravinder Sehgal, Lisa Tell, and Holly Ernest. **Hemoparasites: Determining prevalence in Rocky Mountain Broad-tailed Hummingbirds.** UWyo Undergrad Research Day Apr 2019
2018	* Multiple lab members' talks and posters at Wyoming Wildlife Society (TWS) meeting**. Population Genomics of Bighorn sheep, Pronghorn, Hummingbirds, Great Gray Owls,** etc. Nov 2018. Laramie, WY
2018	*Roderick Gagne, Daryl Trumbo, Melanie LaCava, Patricia Salerno, Christopher Kozakiewicz, Winston Vickers, Seth Riley, Walter Boyce, Kevin Crooks, Chris Funk, Sue VandeWoude, Holly Ernest. **Comparative landscape genomics of mountain lion populations across an urban landscape.** Ecological Society of America Annual Conf. Aug 2018New Orleans, Louisiana, USA.
2018	*Erick Gagne and coauthors. NSF-Ecology and Evolution of Infectious Disease (EEID) **"Genomics identify landscape variation of host and viral spread in urban landscapes"),** Scotland. June 2018.
2018	*Melanie LaCava, Sierra M. Love Stowell, Roderick B. Gagne, Holly B. Ernest. **Landscape genomic analysis of Wyoming pronghorn informs population biology and nomadic behavior.** Reno, NV. Aug 2018.
2017	* Sierra Love Stowell et al Sep 2017. The Wildlife Society annual conference, Albuquerque, NM. Wyoming **Bighorn sheep** Population Genomics. Talk.
2017	* Multiple lab members' talks and posters at Wyoming Wildlife Society (TWS) meeting**. Population Genomics of Bighorn sheep, Pronghorn, Hummingbirds, Great Gray Owls,** etc. Dec 2017. Jackson, WY.
2017	* Amelia Vazquez, et al Sep 2017. The Wildlife Society annual conference, Albuquerque, NM. **Yellow-billed Magpie population genetics before and after West Nile Virus.** Poster.
2017	John Benson et al. The Wildlife Society annual conference, Albuquerque, NM. **Mountain lion small population extinction modeling.**
2017	*Roderick B Gagne (mtn lion genomics), Kyle Gustafson (state-wide Calif. mtn lion

genetics) to Triennial Mtn Lion Workshop, Estes Park, CO in May 2017.

2017 * Kyle Gustafson, Winston Vickers, Walter Boyce, Holly Ernest. Urban Wildlife Conf, San Diego. June. 2017. **A single migrant enhances the genetic diversity of an inbred puma population.**

2017 *Roderick B Gagne (oral presentation) et al and Holly Ernest: **1000-Sea Otter genetic analysis presentation** at the 10th biennial Sea Otter Conference, Seattle.

2016 *Roderick B Gagne (oral presentation); Winston T Vickers; Patricia E Salerno; Daryl R Trumbo; W Chris Funk; Jeffrey A Sikich; Seth PD Riley; Walter M Boyce; **Holly B Ernest. Improving Resolution of Population Genetic Estimates of Pumas within an Urbanized Landscape**. The Wildlife Society annual international conference, Raleigh, NC Oct 2016.

2016 *Melanie Lacava (poster); Roderick B Gagne; Sierra M Love Stowell; **Holly B Ernest. Development and Application of Population Genomic Tools for Conservation and Management of Wyoming Pronghorn.** The Wildlife Society annual international conference, Raleigh, NC, Oct 2016.

2016 *Braden L Godwin (poster); Lisa Tell; Robert Poppenga; **Holly Ernest. Heavy Metal Concentrations in Wyoming Hummingbirds: An Assessment of Population Health and Status as Sentinel Species.** The Wildlife Society annual international conference, Raleigh, NC, Oct 2016.

2016 **Holly Ernest,** Sierra Love Stowell**.** Genomics for **Bighorn sheep** Conservation and Management. Wyoming Game and Fish Bighorn Sheep Annual Meeting, Burgess Junction, WY. July 2016

2016 *Sierra Love Stowell, **Holly Ernest.** Genomics for **Bighorn Sheep** Conservation and Management. Wyoming Wild Sheep Foundation Annual Meeting, Casper, WY. June 2016

2016 *Melanie LaCava (poster); Roderick B Gagne; Sierra M Love Stowell; **Holly B Ernest. Development of Population Genomic Tools for Conservation and Management of Wyoming Pronghorn**. Biennial Pronghorn Working Group meeting. Montana. 2016

2015 **Ernest HB,** several talks for Wyoming Department of Game and Fish: Landscape Genomics of **Bighorn Sheep**; Landscape Genomics of **Pronghorn.**

2014 **Ernest HB, Hummingbird Health Program takes flight in the Rocky Mountain West.** Jackson Hole Wildlife Symposium. Teton School. Dec 2014.

2014 **Ernest HB,** T. Winston Vickers, Scott A. Morrison, Michael R. Buchalski, Walter M. Boyce. International Wildlife Disease Association conference, Albuquerque, New Mexico, Aug 1, 2104: **Mountain lion genetic health: fractured connectivity and low genetic connectivity threatens a southern California puma (*Puma concolor*) population.**

2014 **Holly B. Ernest (speaker)**, T. Winston Vickers (UCD Wildlife Health Center), Walter M. Boyce (UCD Wildlife Health Center), Seth P. D. Riley (National Park Service-Santa Monica Mountains National Recreation Area), Christopher C. Wilmers (Environmental Studies Division, UC Santa Cruz). May 13, 2014, Triennial 11th Mountain Lion Workshop, Cedar City, UT, talk, "**California's cougar connectivity: genetics informing conservation and management.**

2014 *Michael Buchalski; Asako Y Navarro; Walter M Boyce; T. Winston Vickers; Mathias

Tobler; Lisa Nordstrom; Jorge Alaniz Garcia; Daphne A Gille; Maria Cecilia T Penedo; Oliver A Ryder; **Holly B Ernest. Genetic population structure of Peninsular bighorn sheep (*Ovis canadensis nelsoni*) indicates substantial gene flow across US-Mexico border.** Society for Mammalogy. Norman Oklahoma. Aug 2014.

2012 *Micheletti C, Goldberg L, **Ernest H**. Reconstructing 130 years of genetic diversity in California pumas: historic DNA from museums for conservation genetics Merck-Merial Veterinary Scholar National Symposium. (poster)

2012 *Loreto Godoy, Lisa Tell, Barbara Robinson, Rita Colwell, Susan Wethington, Lisa Goldberg, and **Holly Ernest**. **Investigation of a Debilitating Disease Syndrome of Unknown Cause in Wild Hummingbirds**. En Cuentros Conference. San Francisco. Nov 2011.

2011 ***Ernest H.,** Goldberg L, Godoy L, Stice M, Wethington S, Colwell R, Robinson B, Engilis A, Truan M, Tell L, Aigner P, and Kohler C. Conservation **Genetics in Hummingbirds: Species identity, population structure, and genetic diversity for ecology of hummingbirds**. The Wildlife Society Annual Conference. Kona, HI. Nov 2011.

2011 *Goldberg L, Blumenshine K, Heeg E, Morrison S, Vermeer L, Sweitzer R, Updike D, Gilliland T, Godoy L, Marsden C, Gille D, Beardsley K, **Ernest H. Population Genetics of California's Wild Pigs**. The Wildlife Society Annual Conference. Kona, HI. Nov 2011.

2010 ***Ernest H.,** L Goldberg, L Lam, T Gilliland, M Miller, E Dodd, D Jessup. **Toward testing associations: molecular genetic profile, kinship, and disease status in southern sea otters**. Wildlife Disease Association 59th Annual Conference. Iguazu, Argentina.

2009 *Harmeling B, Goldberg L, **Ernest H**. West Nile virus and the Yellow-billed Magpie. Did genetic diversity decrease following the onset of a high mortality infectious disease in California endemic birds? Merck-Merial Veterinary Scholar National Symposium. (poster)

2009 *Hull J, J Keane, W Savage, E Jepsen, **H Ernest**. Isolation and divergence of southern Sierra Great Gray Owls. The Wildlife Society Willow Flycatcher-Great Gray Owl Workshop, Truckee, CA (oral)

2009 *Hull J, J Keane, W Savage, E Jepsen, **H Ernest**. Great Gray Owl population genetics in western North America. 2009 Annual Conference of the Western Section of the Wildlife Society, Sacramento

2009 *Lam L, Kurushima J, Miller M, Jessup D, Dodd E, Goldberg E, and ***Ernest HB.** DNA Markers To Test Genetic Associations in Southern Sea Otters with Cardiac Disease. Annual Sea Otter Research Symposium. Monterey, CA (poster)

2009 *Crosbie S, **Ernest H**. California Birds and West Nile Virus. Sagehen Summer Speaker Series. (oral)

2009 *Crosbie S, **Ernest H**. Status of the Yellow-billed Magpie. US Fish and Wildlife Service speaker series. (oral)

2009 *Goldberg LS , Blumenshine KM, Heeg ER, Morrison SA, Vermeer LA, Sweitzer RA, Updike DR, Gilliland T, **Ernest HB.** Genetic diversity of California's island feral pigs. International Plant and Animal Genomes XVII. San Diego, CA (poster)

2008	* **Ernest HB.** Integrating Genetic Tools In Disease Ecology. Wildlife Disease Association Annual Conference. Edmonton, Alberta. (oral)
2008	* **Ernest HB.** Integrating Genetic Tools In Disease Ecology. Center for Disease Modeling and Surveillance, UC Davis. (oral)
2008	*Crosbie S, **Ernest H**. Yellow-billed Magpie: Post-WNV Abundance and Habitat Use. Yolo Audubon Society. (oral)
2008	*Crosbie S, ***Ernest H**. (joint presentation) Yellow-billed Magpie: Endemic “Island” Species in Sea of WNV. The Nature Conservancy Island Scrub-Jay Workshop. (oral)
2008	*Hull J, J Keane, and **H Ernest**. Molecular genetic tools for use in the conservation of Great Gray Owls. Yosemite Great Gray Owl Management Workshop, Yosemite National Park (oral)
2008	*Jepsen E, Keane J, Maurer J, **Ernest H,** Occupancy, Reproduction and Nest-Site Habitat of Great Gray Owls in the central Sierra Nevada, 2004-2007. Yosemite Great Gray Owl Management Workshop, Yosemite National Park (oral)
2007	*Crosbie S, **Ernest H**. Monitoring Magpie Abundance and Habitat Associations Post-WNV. Central Valley Birding Symposium. (oral)
2006	***Ernest H**. North American Ornithological Conference-Emerging Infectious Disease Symposium. Impact of West Nile virus on the Yellow-Billed Magpie. Veracruz, Mexico. (oral)
2006	***Ernest HB**. Magpie Monitors Workshop. For citizen scientist volunteers. West Nile Virus and the Yellow-billed Magpie: Why are magpies at risk of decline? Davis. (oral)
2006	***Ernest HB**. The Wildlife Society Western Section. West Nile Virus, Genetics, and the Yellow-billed Magpie. Sacramento. (oral)
2006	*Scott Crosbie, **Ernest HB** Sandhill Crane Festival. Invited presentation by PhD student, West Nile Virus and Yellow-billed Magpies. (oral)
2006	*Hull JM, **Ernest HB.** Golden Gate Raptor Observatory. Conservation Genetics of Swainson’s Hawks. (oral)
2006	*Hull J, **Ernest H.** The Wildlife Society, Sacramento-Shasta chapter. Conservation Genetics of Swainson’s Hawks. Sacramento. (oral)
2006	*Hull J, **Ernest H.** North American Ornithological Conference-Raptor Conservation Symposium. Conservation Genetics of Swainson’s Hawks. Veracruz, Mexico. (oral)
2006	*Pitzer, S, Hull J, **Ernest H**. North American Ornithological Conference-Raptor Conservation Symposium. Fall migration in monomorphic raptors: utilizing gender determination techniques. Veracruz, Mexico. (oral)
2006	*Heeg E, Updike D, **Ernest HB.** Ecological Society Annual Conference. Presentation by MS student Elizabeth Heeg. The landscape genetics of invasion: a study of California wild pigs. Memphis, TN. (oral)
2006	*Heeg E, Updike D, **Ernest HB.** Annual Wild Pig Conference. Presentation by MS student Elizabeth Heeg. The landscape genetics of invasion: a study of California wild pigs. Mobile, AL. (oral)
2006	*Multiple and **Ernest H.** The Wildlife Society Western Section. Annual Meeting. Coauthored presentations by my students. Elizabeth Heeg (Population genetics of feral pigs), Sarah Pitzer (Construction of key to sex raptors: genetics and morphology), Sarah Brown (Black bear population genetics), Joshua Hull (West

Nile virus in raptors), Jennifer Kurushima (Puma DNA panel for ecology). Sacramento, CA. (oral)

2005 ***Ernest HB.** Yellow-billed Magpie Workshop. Genetics, West Nile virus and the Yellow-billed Magpie. Davis. (oral)

2005 ***Ernest HB,** O'Rourke K. Wildlife Disease Association. Kinship genetics of deer with Chronic Wasting Disease (poster); ***Ernest HB.** West Nile virus and genetics in Yellow-billed Magpies (oral). Australia.

2005 ***Ernest HB,** West Nile Virus Conference. Pathology associated with West Nile Virus Infections in a California Endemic Bird: the Yellow-billed Magpie. With co-authors, Leslie Woods DVM PhD, Jay Well1, Vicki Kramer PhD, Ryan Carney, Barbara Calhoun-Young PhD, William Reisen PhD, Gerald Wiscomb. San Jose, CA. (oral)

2005 *Hull J, **Ernest H.** Sonoma State University Colloquium**.** West Nile Virus Antibody Prevalence in California Raptors. (oral)

2005 *Hull J, **Ernest H.** Cooper Ornithological Society Annual Meeting. West Nile Virus Antibody Prevalence In California Raptors. Presentation by PhD student Joshua Hull. Arcata, CA.

2005 *Multiple and **Ernest H.** Genetic Monitoring Workshop**,** for California Department of Parks and Recreation and Genetic Resources Conservation Program. Audience: state and federal wildlife and environmental agency biologists and administrators. Genetic Monitoring of Wildlife: Mammals and Birds. Co-authored presentations by my students. Elizabeth Heeg (Population genetics of feral pigs), Sarah Brown (Black bear population genetics), Joshua Hull (West Nile virus in raptors); Post-doctoral scholar Dr. Ben Sacks (Coyote population genetics).

2004 ***Ernest HB,** USDA Wildlife Service Annual Conference. Applications of Genetics and Disease Ecology for Wildlife Management. Yosemite National Park. (oral)

2004 Collins J, ***Ernest H. International Society for Animal Genetics Biennial Conference**. Microsatellite Marker Panel for Puma (*Puma concolor*): Development and Applications for Ecology and Forensics. Tokyo.

2004 *Sacks B, Brown S, **Ernest H.** Your genes may flow but the coyote carries hers. **Bay Area Conservation Biology Annual Conference.** Berkeley, CA.

2003 ***Ernest HB.** American Genetics Association Conservation Genetics Conference (first annual). Genetic Structure of Mountain Lion Populations in California and Nevada. Front Royale, VA. (oral)

2003 ***Ernest HB,** Wictum E. California Association of Criminalists Annual Conference. Solving Crimes using Animal Genetics. Reno, NV. (oral)

2002 ***Ernest HB.** Carnivores Annual Conference. Genetic Structure of Mountain Lion Populations in California and Nevada. Monterey, CA. (oral)

REPORTS AND MAGAZINE ARTICLES

- **Forensic genetic evidence case reports submitted to law enforcement agencies (25 cases) and private parties involved in civil law suits (20 cases).** Casework presented from federal, state, and local law enforcement agencies as well as to the general public to the Forensic Unit of the Veterinary Genetics Laboratory. 2002-2003.

- **Population genetics of Nevada mountain lions.** Nevada Division of Wildlife contract. 2002. H. Ernest
- **Review of Mountain Caribou Captive Breeding Plan** for British Columbia Ministry of Water, Land & Air Protection. 2001. H. Ernest
- **Contingency Captive Breeding Plan for Sierra Nevada Bighorn Sheep.** Holly Ernest. Final Report submitted to the California Department of Fish and Game. Population viability analyses, genetic recommendations, decision trees, facility site assessments, veterinary care, husbandry, selection of founder breeding stock, review of diseases, and reports on existing captive bighorn sheep facilities. 2001.
- **DNA analysis for mountain lion conservation.** Holly Ernest. *Outdoor California*. May-June. 61(3)16-19. Invited article. 2000.
- **DNA sampling and research techniques.** Holly Ernest. *Outdoor California*. May-June. 61(3)20-21. Invited article. 2000.
- **Eastern cougar DNA identification reports to state agencies**. DNA identification of samples from Kentucky and Missouri. H. Ernest. Genetic assignment analysis for population source of cougars. Reports to Kentucky and Missouri state wildlife departments. 1999.
- **Forensic DNA report.** Microsatellite DNA analysis of forensic samples taken from a human fatality due to mountain lion attack in Canada. H. Ernest. Report submitted to the British Columbia Ministry of the Environment and California Department of Fish and Game. 1997.

WEBSITES

Development and maintenance

- **http://www.wildlifegenetichealth.org and over 30 educational web pages. 2015-present.**
- **Active blogging presence on WildlifeGeneticHealth twitter 2015-present. https://twitter.com/hollyernest**
- **Active blogging presence on Facebook 2015-present. https://www.facebook.com/wildlifegenetichealth/**
- **Hummingbird Health Program**. 2011-present, developed program and website.
- **Magpie Monitor**. Public education and citizen science information about the Yellow-billed Magpie, a species found only in central California, and its health and population risks due to West Nile virus. Internet portal. 2004-2011. Transitioned material that was on dedicated non-campus web site to my faculty web sites.
- **UC Davis Wildlife Population Health and Ecological Genetics**. Portal, information.

PUBLIC, NATIONAL AND INTERNATIONAL SERVICE

2017-present Wildlife Disease Assoc. Council member. https://www.wildlifedisease.org

2017-present. Invited participant, and voted member of Federal NIST OSAC **Wildlife Forensic working group**, Reston, VA. Federal wildlife forensic consultant. OSAC Forensics = Organization of Scientific Area Committees for Forensic Science. https://www.nist.gov/topics/forensic-science/osac-subcommittees - click on "wildlife forensics"

2010-present **Assoc. Editor, Conservation Genetics journal.** https://link.springer.com/journal/10592

2014-2016 **Secretary, Wildlife Veterinary Section of Wildlife Disease Assoc**.

2010-present Bander, hummingbirds, contributing data and health information to Hummingbird Monitoring Network.

2008-2011 Board member, Hummingbird Monitoring Network

2008-2009 Volunteer hummingbird bander, UC McLaughlin Nature Reserve Hummingbird Banding Station

2008-2011 Wildlife Disease Association student awards committee

2007-2009 **Member, Great Gray Owl Interagency Working Group** (National Park Service, USDA Forest Service, Calif. Department of Fish and Game).

2004-2012 **Founded and coordinate citizen science group - Magpie Monitors.** Educate and involve the public in bird conservation and monitoring. Involvement of ages (school kids to retirees).

2002-2008 **Print and televised/online media interviews. Discovery Channel** televised 2009 featuring our wild pig population genetic research and ecological destruction due to invasive feral hogs; show entitled "Pig Bomb"). **West Nile virus and bird populations** (2004-2008)**:** newspapers, TV/online (San Francisco and Sacramento stations. Regular telephone and email communications with the public and press on wildlife health and genetics issues.

2005 **Organized and moderated Interagency Yellow-billed Magpie Scientist Workshop.** Attendees: US Fish and Wildlife Service, California Department of Fish and Game, Audubon Society (California HQ), PBRO-Conservation Science, UC Berkeley, Cal State Stanislaus, The Nature Conservancy, UC Riverside, Sacramento-Yolo Mosquito and Vector Control District, and others. Coordinated production of white paper presented to state agencies.

2006 **Organized and moderated Magpie Citizen Science Education Workshop.**

2005-2006 **Member, Peninsular Bighorn Sheep Recovery Team Subcommittees, US Fish and Wildlife Service, southern California:** 1) Disease outbreaks 2) Captive breeding, translocation, and reintroduction.

2006 **Bird Conservation and Biology booth at Sacramento Zoo.** Interactive exhibit for adults and children.

2002-2003 **Court Testimony Expert Witness** at kidnap-murder trial in San Diego. Testified on analysis of animal DNA forensic evidence.
Expert Witness at dog mauling child fatality grand jury hearing. Testified on analysis of animal DNA forensic evidence.

1994-1997 Teaching at California Department of Fish and Game (CDFG) Wildlife Handling and Restraint Courses – assisted in training of wildlife rehabilitators, animal damage control officers, wildlife biologists, **California Department of Fish and Game**

REVIEW SERVICE

2006-present. **Grant Reviews:** National Science Foundation, US Geological Service-Anchorage AK, National Science Foundation, Oiled Wildlife Care Network, and others.

2003 **Invited reviewer of US Fish and Wildlife Service:** science document and plan recovery of endangered Florida panther recovery

2002-2003 Lead reviewer of a research **proposal animal care and use research protocols to ensure humane use of wildlife species in research**; for the Western Ecological Research Center, U. S. Geological Service, and the UC Davis Wildlife Health Center.

2002-present.*Adhoc* manuscript reviewer for journals (generally in wildlife genetics and health, plus other topics as noted): American Midlands Naturalist, Animal Conservation, Animal Ecology, Journal of Animal Science (also rare sheep breed genetics), Behavioral Ecology and Sociobiology, Canadian Journal of Zoology, Journal of Field Ornithology, Conservation Biology, Conservation Genetics (also rare cattle breed genetics), Ecological Applications (also ungulate ecology), Evolutionary Applications, Journal of Wild and Zoo Animal Medicine, Journal of Wildlife Management, Journal of Wildlife Diseases, Mammalogy, Molecular Ecology (also ecological and trace DNA genetics), PlosONE, Veterinary Research, Western North American Naturalist, and others.

UNIVERSITY SERVICE (UNIV. OF WYOMING)

2014-present Various years of service: College of ANR Tenure and Promotion committee (2017-2018); Program in Ecology steering committee, Department of Veterinary Sciences Faculty Search Chair (Parasitologist), graduate student committees, Pre-veterinary advising; Program in Ecology curriculum committee, Department of Veterinary Sciences Faculty Search Chair, Faculty Search Committee for Dept of Animal Sciences, Graduate student committees, Pre-veterinary advising. Starting after Fall 2016: Tenure and Promotion Committee for School of Agriculture and Natural Resources.

UNIVERSITY SERVICE (UC DAVIS)

Including School of Veterinary Medicine (SVM), Department of Population Health and Reproduction (VM:PHR), Veterinary Genetics Laboratory (VGL)

2013-2014 UC Davis One Health Institute and Wildlife Health Center Senior Staff committee

2008-present SVM Population Health curriculum committee

2010-2012 John Muir Center for the Environment Advisory Committee

2006-2011 SVM Ecosystem Health curriculum Working Group

2002-2014 VGL Executive Committee; then Scientific Advisory Committee (2014)

2005-present Various Department Committees (Personnel, Curriculum, Equipment & Resources, etc)

2006-2009 SVM International Student Programs Committee
2006-2007 Search Committee, VGL Forensic Unit Associate Director (2006-7)
2005-2007 Department VM:PHR Curriculum committee
2002-2003 Coordinator and member of steering committee for UC Davis research working group, Effects of West Nile Virus on Wildlife Health and Ecology

PROFESSIONAL SOCIETIES & ORGANIZATIONS (CURRENT/OR RECENT MEMBERSHIP)

- American Association for the Advancement of Science
- American Association of Wildlife Veterinarians
- American Ornithologists Union, Cooper Ornithology, Wilson Ornithology
- Ecological Society of America, Wildlife Disease and Molec. Ecology Sections
- Raptor Research Foundation
- Society for Field Ornithologists
- Society for Wildlife Forensic Science
- Society for the Study of Evolution
- The Wildlife Society, national and regional, Wildlife Disease and Molec. Ecology Sections
- Wildlife Disease Association, including Wildlife Veterinary Section

UNIV. OF WYOMING AFFILIATIONS (2014 TO PRESENT)

- Department of Veterinary Sciences (home department)
- Program in Ecology
- Haub School of Natural Resources and the Environment

UC DAVIS AFFILIATIONS (2002 TO 2017)

Department of Population Health & Reproduction (home department, including permanently as Emeritus Professor). Center affiliations officially through 2014, with continued collaborations: One Health Institute, Wildlife Health Center, John Muir Center for the Environment, Veterinary Genetics Laboratory, Center for Vectorborne Diseases.

VETERINARY AND FIELD ECOLOGIST EXPERIENCE

- **Federally permitted hummingbird bander**. 2009-present. Hummingbird capture, sampling, and banding in Arizona, Colorado, and California. Awarded Master Bander certificate by USGS in 2011.
- **Foreign Animal Disease readiness.** Representative from Wildlife health Center to California state committee: working group of wildlife and state-federal agency veterinarians and biologists to plan readiness in California for potential threats of introduction of Foot and Mouth Disease and other foreign animal diseases to wildlife. 2001.
- **Veterinarian, capture team member for wildlife captures and surveys**. U.S. Fish and Wildlife Service, USFWS capture of endangered desert **bighorn sheep**, San Andres Mountains, New Mexico, September 1999. Base camp veterinarian and helicopter capture team member, CDFG bighorn sheep captures, Eagle Mountains, Mojave Desert, 1993; Anza Borrego Desert State Park, 1993 and 1997; Peninsular Ranges of southern CA, 1996.

Restraint and sample collection of captive bighorn sheep for a hematological and disease survey Living Desert Museum, Palm Desert, CA, 1994. Base camp veterinarian and team leader of helicopter capture crews for two mule deer netgun captures (140 deer in eastern Sierra Nevada Mountains).

- **Veterinary and genetics advisor** to the Yosemite National Park Mountain Lion Project. Trained park service personnel in mountain lion capture, handling, restraint, safety issues. Performed genetic typing of radiocollared lions and scats collected from hiking trails. 1995 to 1999.
- **Veterinary advisor and surgeon** for USGS-Biological Resource Division Project on endangered Giant Garter Snakes, a water snake endemic to a narrow band in California's Sacramento Valley. Surgical implantation of radios for telemetry, disease investigations. 1997-99.
- **Wildlife Disease Investigation:** Performed on-site investigation of **bighorn sheep** die-off (at least 45 animals, botulism) in Mojave Desert for the California Dept of Fish and Game; member of the team which planned the outbreak investigation, collected diagnostic samples, planned diagnostic tests, and with Dr. Randy Singer and Dr. John Wehausen wrote up case for publication in J. Wildlife Diseases. September 1995.