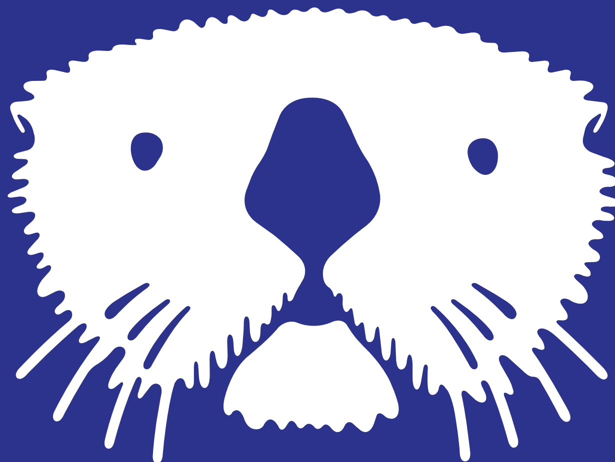

SEA OTTER CONSERVATION

WORKSHOP XI

MARCH 29–31, 2019

Conference Proceedings

SEATTLE AQUARIUM

Inspiring Conservation of Our Marine Environment

Time	Title	Presenter/moderator	Session theme
Friday, March 29			
2pm	Welcome remarks	Shawn Larson, Traci Belting, Erin Meyer and Bob Davidson	
	SESSION ONE	Shawn Larson	
2:10pm	Southern sea otter status as indicated by recent surveys and strandings	Brian Hatfield	Population status
2:30pm	Washington northern sea otters: population and causes of mortalities summary	Deanna Lynch	Population status
2:50pm	A Bayesian model of Washington sea otter population dynamics	Jessica R. Hale	Population status
3:10pm	Conservation success, now what? Challenges of maintaining long-term population surveys for a species with an expanding range.	Linda Nichol	Population status
3:30pm	The return of sea otters along the coast of eastern Hokkaido, Japan	Yoko Mitani	Population status
3:50pm	*Questions*		
4pm	*Break*		
	SESSION TWO	Traci Belting	
4:20pm	Predicting habitat-specific carrying capacity (K) and incorporating multiple data types into an integrative population model (IPM) to support sea otter management	Tim Tinker and Lilian Carswell	Ecology
4:50pm	An ecological assessment of a potential sea otter reintroduction to Oregon	Dominique Kone	Conservation
5:10pm	The Elakha Alliance: seeking to restore sea otters to Oregon	Robert Bailey	Conservation
5:30pm	Developing a blueprint for sea otter restoration in the state of Oregon: making a case for collaborative and place-based adaptive strategies	Valerie Stephan-Leboeuf	Conservation
5:50pm	Assessing anthropogenic risk to sea otters for reintroduction into San Francisco Bay	Jane A. Rudebusch	Conservation
6:10pm	*Questions*		
6:20pm	Round-table discussion—new re-introductions	Panel members: Shawn Larson, Jim Bodkin, Tim Tinker, Jim Estes and Lillian Carswell	Conservation
6:40pm	*Adjourn to Aquarium exhibit spaces for dinner/evening event*		
7:30pm	Keynote address: 50 years of research on sea otters and coastal ecosystems: history and high points	Jim Estes	Conservation
Saturday, March 30			
	SESSION THREE	Caroline Hempstead	
8am	The relationship between researchers and youth in sea otter conservation	Dakota Peebler and Grace Jones	Conservation
8:20am	The global sea otter (Enhydra lutris) conservation strategy, IUCN-SSC Otter Specialist Group	Angela Doroff	Conservation
8:40am	Future directions in sea otter research and management	Randall W. Davis	Conservation
9am	Sea Otter Savvy: building community stewardship	Gena Bentall	Conservation
9:20am	Monterey Bay Aquarium sea otter research and conservation: where we are at with surrogacy and reintroductions	Michelle Staedler	Conservation

Time	Title	Presenter/moderator	Session theme
9:40am	Husbandry challenges during adaptation period of two young sea otters (Enhydra lutris kenyoni) at Oceanário de Lisboa	Hugo Batista	Husbandry
10am	*Questions*		
10:10am	*Break*		
	SESSION FOUR	Catlin Hadfield	
10:30am	A model preventive medicine program for sea otters	Michael J. Murray, DVM	Veterinary
10:50am	The dead do tell tales! Investigating southern sea otter (Enhydra lutris nereis) mortality patterns (1998–2012)	Melissa A. Miller	Veterinary
11am	Longitudinal assessment of domoic acid exposure and relative hazard of death due to cardiomyopathy in southern sea otters (Enhydra lutris nereis)	Megan E. Moriarty	Veterinary
11:20am	Esophageal perforation in a southern sea otter (Enhydra lutris nereis)	Lauren T. Michaels	Veterinary
11:40am	Uterine leiomyoma, cystic endometrial hyperplasia and endometriosis in a northern sea otter (Enhydra lutris lutris)	Megan M. Strobel	Veterinary
Noon	Validation of an animal-side serum amyloid A ELISA for the evaluation of systemic inflammation in sea otters (Enhydra lutris)	Kendal Harr	Veterinary
12:20pm	*Questions*		
12:30pm	*Lunch: reconvene at 1:30*		
	SESSION FIVE	Julie Carpenter	
1:30pm	Facilities updates—highlights from Friday's breakout session	Traci Belting	Husbandry
2:00pm	Aging sea otters using dental growth patterns, tooth wear patterns and growth plates from x-rays	Teri Nicholson	Veterinary
2:20pm	Investigating potential dietary links to changes in serum liver parameters in sea otters	David A. S. Rosen	Veterinary
2:40pm	Top-level carnivores linked across the marine/terrestrial interface: sea otter haul-outs offer a unique foraging opportunity to brown bears	Daniel Monson	Ecology
3pm	Where carnivores clash: evidence of competition—prey-shifting by brown bears during a period of sea otter recovery	Heather Coletti	Ecology
3:20pm	Long-term trends for sea otters on the Pacific Northwest coast from archeological remains and traditional knowledge: ecological and indigenous histories before the maritime fur trade	Iain McKechnie	Ecology
3:40pm	*Questions*		
3:50pm	*Break*		
	SESSION SIX		
4:10pm	#TeamOpenCoast or #TeamEstuary? : The costs and benefits of two key sea otter habitats	Jessica Fujii	Ecology
4:30pm	Revisiting the role of southern sea otters in California kelp forests	Sophia Lyon	Ecology
4:50pm	Sea otter diet composition with respect to recolonization, demographic and seasonal patterns in southern southeast Alaska	Nicole LaRoche	Ecology

Time	Title	Presenter/moderator	Session theme
5:10pm	Velocity of community shift and alternative kelp forest states: how long-term subtidal monitoring can focus dialogue surrounding nearshore conservation and management	Zachary Randell	Ecology
5:30pm	New tagging technology for sea otter research: an update on OtterNet	Joseph Tomoleoni	Ecology
5:50pm	*Questions*		
6pm	Adjourn and reconvene at Argosy cruises at 7:30pm for Puget Sound cruise (appetizers and cash bar)		

Sunday, March 31

	SESSION SEVEN	Carol Jackson	
8am	Roundtable discussion—the placement of rehabilitated pups	Panel members: Traci Belting, AZA Sea Otter SSP, Monterey Bay Aquarium and Alaska Sea Life Center	Conservation
8:20am	The complex role of sea otters in southeast Alaska	Ginny Eckert	Ecology
8:50am	Sea otter recolonization associated with regional increase in kelp forest canopy	Tom W. Bell	Ecology
9:10am	Reproductive physiology and energetics of sea otters	Nicole Thometz	Physiology
9:30am	Anatomy of the sense of touch in sea otters	Sarah McKay Strobel	Physiology
9:50am	Beyond morbidity: an integrated approach to sea otter intestinal parasitism	Kyle Shanebeck	Ecology/ Physiology
10:10am	*Questions*		
10:20am	*Break*		
	SESSION EIGHT	Kelli Lee	
10:40am	IUCN global otter conservation strategy	Nicole Duplaix	General
11am	Sea otter toxicology research: what can we learn about toxic compounds in sea otters using non-invasively collected fecal samples?	Amy Olsen	Physiology
11:20am	Investigating the energetic cost of anthropogenic disturbance on the southern sea otter (Enhydra lutris nereis)	Heather E. Barrett	Physiology
11:40am	Investigating microplastic ingestion in sea otters through scat analysis	Jennifer Van Brocklin	Physiology
Noon	Using behavioral and physiological data to evaluate animal welfare in marine mammals: a case study on sea otters	Megan Hagedorn	Physiology
12:20pm	*Questions*		
12:40pm	*Lunch: reconvene at 1:40*		
	SESSION NINE	Amy Olsen	
1:40pm	Genetic analyses of southern sea otters inform the present and illuminate the past	Roderick B. Gagne	Genetics
2pm	Investigating the relationship between genetics and disease outcome in necropsied southern sea otters (Enhydra lutris nereis)	Nicole H. Carter	Genetics
2:20pm	Sea otter genetics update: diversity, population structure and taxonomy	Shawn Larson	Genetics
2:40pm	*Questions and adjourn*		

The return of sea otters along the coast of eastern Hokkaido, Japan

***Yoko Mitani*[1], *Yudai Kitano*[2], *Ippei Suzuki*[1], *Randall Davis*[3]**

1: Field Science Center for Northern Biosphere, Hokkaido University

2: School of Fisheries Science, Hokkaido University

3: Dept. of Marine Biology, Texas A&M University at Galveston

Sea otters in Japan were hunted to near extinction during the maritime fur trade in the 19th and early 20th centuries before receiving protection in 1911. Periodic sightings have occurred during the past 20 years along the east coast of Hokkaido, but there has been no concerted effort to document their recovery. In the summer and autumn 2018, we conducted a census of sea otters along the east coast of the Nemuro Peninsula including islands. They fed on sea urchins (*Strongylocentrotus intermedius*), crabs (*Paralithodes brevipes* and *Telmessus cheiragonus*) and sea squirts, but clams (*Mactra chinensis* and others) were thepredominate (70%) prey. Thirty-minute focal follows showed that they spent 31% foraging, 34% resting, 20% grooming and 16% transiting/patrolling. It is likely that this small population will continue to expand in an area of commercially valuable invertebrates, so policies to mitigate conflict should be anticipated.

Sea otter toxicology research: what can we learn about toxic compounds in sea otters using non-invasively collected fecal samples?

Amy Olsen

Pollutants and other toxic contaminant compounds are found in ecosystems throughout the world, from the Arctic to the Mariana Trench. These chemicals have been associated with negative health effects in wildlife, including those that live in the marine environment. Sea otters are a marine predator with a high metabolism, and extensive consumption of contaminated prey may result in biomagnification of these toxic compounds. The Seattle Aquarium houses four Northern sea otters, and their diet includes a variety of restaurant quality seafood. The Aquarium measured three chemicals for trial testing, all known to cause adverse health effects in high concentrations: polybrominated diphenyl ethers (PBDEs, a flame-retardant used in furniture and electronics), polychlorinated biphenyls (PCBs, a coolant and lubricant), and pyrethroids (a common synthetic insecticide). Seafood diet items and non-invasively collected fecal samples were tested. Overall, values of the three chemicals were found to be below the threshold for concern in humans for all sample types. There is no known threshold for concern in sea otters, so human concern values were used as a proxy. Seattle Aquarium sea otters were ingesting levels below the daily oral limits set by the EPA and World Health Organization. Pyrethroids were the highest measured chemical overall, most likely because PCBs and PBDEs have been managed or fully banned in Washington for 40 and 10 years, respectively, while pyrethroids are still permitted for use both residentially and commercially. The Seattle Aquarium will use these data to improve our animal care by providing our animals with the cleanest sources of food and water, and to serve as a foundation for understanding sea otter toxicology.

The global sea otter (*Enhydra lutris*) conservation strategy, IUCN-SSC Otter Specialist Group

Angela Doroff, Shawn Larson and Nicole Duplaix

Since 1974, the IUCN-SSC Otter Specialist Group has implemented otter conservation programs and has seen many successes but also has witnessed the sharp acceleration of environmental threats that affect otters everywhere: pollution, deforestation, overpopulation, illegal trade, limited protection, and the escalating effects of climate change. In the *2018 Global Otter Conservation Strategy*, we are moving forward with a holistic conservation approach. The goal is to build collaboration among researchers, educators, captive population specialists, legal and policy experts, habitat conservation specialists, and to use social science tools for connecting to all sectors of society in order to support maintaining healthy otter populations. With the goal in mind, we identified threats and mitigation measures, highlighted captive programs, and population success stories for sea otters (*Enhydra lutris*). We identified projects and funding opportunities by country. Common themes among funding for regions were: species coordination (social science), surveys to document population status and trends, competitive graduate fellowships for wild population and captive research, and travel to attend, present, and conduct outreach and education.

Southern sea otter status as indicated by recent surveys and strandings

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The southern sea otter population has been counted each spring using the same methods since 1983. We use a three-year running average of the total number of sea otters counted in spring surveys along the mainland and at San Nicolas Island to derive the range-wide index of relative abundance, which is now 3128, down from 3186 in 2017. Regional trends vary, but the overall 5-year trend remains slightly positive in 2018. The sea otter's population range has remained unchanged for a decade. The effort to document all stranded southern sea otters continued. The number of beach-cast sea otter carcasses and live strandings in California continued at an elevated rate in 2018, with the per capita strandings over the last 3 years being above 14% (the number of strandings divided by the 3-year running average of the mainland spring count). Sea otter mortality from white shark bite also continued at high levels in 2018, especially near both ends of the range. This mortality is likely a significant factor in the lack of range expansion.

All participants in California sea otter surveys, carcass recovery, and necropsy efforts (primarily members of CA Dept. of Fish and Wildlife, Monterey Bay Aquarium, and The Marine Mammal Center) are acknowledged.

How does a small aquarium on the Oregon Coast make an impact on sea otter conservation?

Brittany Blades

This is a question that the Oregon Coast Aquarium Marine Mammal Department was determined to answer after staff attended the Sea Otter Conservation Workshop in 2017.

Sea otters are heroes of near shore ecosystems and what can local Oregonians or even tourists do to help these heroes? Instead of solely mentioning reducing and reusing staff has instead encouraged guests to take photographs or videos of sea otters spotted along the Oregon coastline. After asking guests to send in this documentation, two successful sea otter sightings were reported 1-2 hours south of Newport, OR. By encouraging guests to look for sea otters, we have seen the impact of the messaging we deliver to guests every single day through our presentations. Because of this, we have begun to think of how else we, as zoos and aquariums, can contribute to conservation efforts for sea otters along the Oregon coastline.

In October 2018, the Elakha Alliance hosted the Sea Otter Symposium in Newport to discuss key questions about possible reintroduction to Oregon in the future. This provided the opportunity for Oregon Coast Aquarium staff to be involved in the discussion about the steps towards the potential return of sea otters. Oregon Coast Aquarium staff members are looking forward to playing a supporting role in this effort by educating guests about sea otters being native to Oregon.

Oregon Coast Aquarium has fundraised money to improve the current sea otter habitat. Designs are in place for a new sea otter holding pool. Currently, Oregon Coast Aquarium has no space to quarantine a rescued sea otter. Construction of this new holding pool will allow for the Marine Mammal Department to take on an additional rescued sea otter and manage the current population. In addition, funds are currently being raised for a Marine Wildlife Rehabilitation Center. This will serve as a resource for staff rehabilitating injured or stranded marine mammals and could be used as a potential holding space for sea otters as needed.

The relationship between researchers and youth in sea otter conservation

By Dakota Peebler (13 yrs.) and Grace Jones (14 yrs.)

Join Heirs to Our Oceans youth leaders who focus on sea otter conservation – Dakota Peebler and Grace Jones – at an exciting, engaging and informative presentation about how the next generation working with scientists, researchers and policy makers can make great change together for our oceans and waterways. Dakota and Grace will share what they and Heirs To Our Oceans have done to date in sea otter conservation and ocean protection through meaningful collaboration with professionals, and they will demonstrate what they as diverse young leaders can bring to the table in discussion of environmental protection including sea otter conservation.

Top-level carnivores linked across the marine/terrestrial interface: Sea otter haul-outs offer a unique foraging opportunity to brown bears

Daniel Monson, Rebecca Taylor, Grant Hilderbrand, Joy Erlenbach and Heather Coletti

Commercial exploitation in the 18th and 19th centuries eliminated sea otters from most of their range including the coastline of what is now Katmai National Park and Preserve (KATM). However, a remnant sea otter population remained north of Cape Douglas, and by the early 1990's sea otters had expanded their range into KATM with the area supporting ~1000 animals. Sea otter abundance has increased approximately seven-fold since the early 1990's and now appears to be approaching carrying capacity. Sea otters along the KATM coast utilize offshore islands as haul out sites where brown bears are also commonly found. Since 2006, we have collected sea otter carcasses from the offshore islands along the KATM coast with most carcasses showing signs of being consumed by brown bears. Population models using the carcass collections as representative sea otter age-at-death data suggest the population should be declining, which contrasts with sea otter surveys that do not suggest a decline over a similar time frame. We deployed remote cameras on two offshore islands and documented brown bears actively preying on both sea otters and harbor seals. We conclude that 1) brown bears occupy offshore islands along the KATM coast to hunt marine mammals, not just to scavenge carcasses, and 2) brown bear predation causes more prime age otter mortality than expected in a typical otter age-at-death distribution, confusing interpretation of population models based on such data. This study highlights a previously under recognized interaction between a top-level marine and terrestrial predator. Future work will focus on the direct and indirect effects these top-level predators have on each other and the intertidal community that connects them.

Investigating potential dietary links to changes in serum liver parameters in sea otters

David A. S. Rosen[1,2], Martin Haulena[2]

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[2]Vancouver Aquarium, Vancouver, BC, Canada

Changes in serum liver profiles indicative of impeded hepatic function was recently observed in a group of young, rehabilitated sea otters maintained on a diet containing a high proportion of shrimp. Unfortunately, the underlying pathology of the original observation was not clear. We investigated whether a diet high in shrimp induces changes in serum liver parameters in sea otters by conducting controlled diet manipulations with a group of 5 managed sea otters (ages 1-6 yrs.) at the Vancouver Aquarium. The otters were fed diets that consisted of their normal food items, but with additional shrimp fed at levels equal to either 20% or 30% of their daily intake by mass. The diets were also manipulated to contain capelin or not, to further manipulate protein: lipid intake levels. Each sea otter was subject to 2 different experimental diets for 2 weeks each, interspersed with a minimum 4-week "recovery" period of their normal diet. Biological samples were obtained at the start and end of each 2-week trial under vet-supervised anesthesia. Blood samples were drawn for determination of standard blood profiles as well as liver function enzymes. Ultrasound and radiograph images were also taken of the liver to quantify any morphological changes attributable to each dietary treatment.

Initial analysis of the blood samples indicates recognizable changes in hematology, biochemistry, and protein C levels, although not all the changes were directly related to liver function. Radiograph and ultrasound image analyses are pending. The results of this study will have direct applicability to the nutritional health and welfare of otters kept under human care. It may also shed light on whether diet specialization is an impediment to range expansion in wild sea otters.

Washington northern sea otters: population and causes of mortalities summary

Deanna Lynch[1] and Steven Jeffries[2]

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Northern sea otters (*Enhdyra lutris kenyoni*) were extirpated along much of the coast of North America by the early 1900s. During the 1960s and 1970s, otters from Alaska were reintroduced along the coasts of Oregon, Washington, and British Columbia. The minimum population estimate in Washington was approximately 2,058 sea otters in 2017, and this population continues to grow at approximately 9.5% per year. In 2017, approximately 80% of the population occurred in a few large rafts within the 40-mile segment of the coast between the Quillayute River and Point Grenville. A centralized stranding response program for voluntary reports in Washington and Oregon began in 2002. Between 2017 and 2018, a total of 75 dead or moribund sea otters were reported, 74 in Washington and 1 in Oregon. Of these, 9 were live strandings, all of which subsequently died or were euthanized. Eleven carcasses that were fresh or moderately decomposed were shipped for necropsy to USGS's National Wildlife Health Center. Of these11 cases, 7 deaths were attributed to protozoal meningoencephalitis due to *Sarcocystis neurona*, 2 were heart-related, and 2 were hepatic necrosis.

An ecological assessment of a potential sea otter reintroduction to Oregon

Dominique Kone[1], Leigh Torres[2], M. Tim Tinker[3]

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From the mid-1960's to early 1970's, managers translocated sea otters from southwest and south -central Alaska to regions from which sea otters had been extirpated during the North Pacific fur trade. Translocations to Southeast Alaska, British Columbia and Washington were successful and have led to growing populations of sea otters in these regions, with associated restoration of ecosystem function. The translocation to Oregon was not successful, as sea otters disappeared shortly following release, but there is renewed interest in another translocation attempt. Given the previous failure and the inherently uncertain nature of species reintroductions, managers seek to gain a better understanding of the potential for coastal habitats to support sea otter populations, factors likely to affect translocation success, and likely ecological impacts, before deciding whether to proceed with such an effort. To inform this process, we are investigating these questions using two methods. First, to investigate the population potential for sea otters in Oregon habitats, and the likelihood of a successful reintroduction, we will estimate sea otter carrying capacity along the Oregon coast. Specifically, we will adapt a habitat-specific carrying capacity model recently developed for southern sea otters, and use this model to determine how many sea otters this area could theoretically support, based on the identification of suitable habitat. Potential sea otter habitats will be further analyzed to assess proximity and spatial overlap with a range of current human-use activities (i.e. fisheries, marine reserves, ports). Second, we will systematically review available scientific literature to assess and qualitatively predict the potential effects of sea otters on Oregon's nearshore ecosystems. We will provide the results of these analyses to resource managers to inform and support the decision-making process, and (if a translocation program is initiated) to help set targets and expectations for sea otter recovery and ecosystem effects in Oregon coastal waters.

Genetic analyses of southern sea otters inform the present and illuminate the past

Roderick B Gagne, M. Timothy Tinker, Katherine Ralls, Shawn Larson, L. Max Tarjan, Melissa A. Miller, Kyle D. Gustafson, Holly B. Ernest

Genetic indices can provide powerful insight into the health, genetic status, and demographic history of populations of conservation concern. We combined demographic information with genotype data on 38 microsatellite loci from 1,006 southern sea otters (*Enhydra lutris nereis*) to address fundamental questions regarding current genetic status and historic mortality events. We used multiple approaches to estimate the effective population size (N_e) and genetic diversity of the population. In the simplest sense, N_e is an estimate of the number of individuals in the population that are contributing genetically and provides a measure of the adaptive potential of the population. N_e estimates are of particular importance in southern sea otters as the subspecies is federally threatened and N_e is part of the delisting criterion. Genetic diversity was low and did not change significantly over time. Notably, the demographic effective population size was much larger than the genetic estimates when based on samples collected throughout the range of the population. However, when the spatial scale of the analysis was constrained to a portion of the range consistent with the movements of individual sea otters (based on tagging data), the demographic and genetic estimates of N_e converged. This finding, coupled with the results of spatially explicit genetic structure analyses, suggests there is subtle genetic structure in the population that was not previously detected. Following assessment of the extant population, we used genetic analyses to estimate the timing of past mortality events that would have resulted in extensive loss of genetic diversity. Our preliminary results agree with previous findings that major population declines had already greatly reduced sea otter genetic diversity prior to the near-extirpation of sea otters during the fur trade.

Sea Otter Savvy: building community stewardship

Gena Bentall, Program Coordinator, Sea Otter Savvy

Sea Otter Savvy is a collaborative outreach and research program focused on addressing the problem of human-caused disturbance to sea otters in three central California counties. Over the last three years this program has made progress fostering collaborative stewardship in coastal communities and has undertaken innovative projects to bring awareness about sea otters and wildlife disturbance to the public. This presentation will feature an overview of accomplishments, challenges, and future plans of the Sea Otter Savvy program.

The complex role of sea otters in southeast Alaska

Eckert, G. L.[1], Ibarra, S.N.[1], Raymond, W.W.[1] Stephens, T.[1], Bolwerk, A.[1], Hughes, B.[2]

1 – University of Alaska Fairbanks

2- Sonoma State University

Sea otters were exterminated from Southeast Alaska during the 19th century maritime fur trade, but after reintroduction in the 1960's, their population grew exponentially and at last count in 2011 included over 25,000 animals. The extirpation of sea otters and subsequent successful return has resulted in ecosystem changes in a wide variety of marine habitats and consequent changes in human behavior. Humans compete with sea otters for commercial and subsistence shellfish and coastal Alaska Native people harvest sea otters. Our social-ecological research documents patterns in sea otter harvest and declines in commercial and subsistence shellfish that correspond with decreases in food security in areas with abundant sea otters. On the other hand, sea otters are ecologically important as keystone species with ecosystem benefits in marine habitats including kelp forest and likely eelgrass meadows. We are investigating the trophic connections and role of disturbance of sea otters in eelgrass meadows, the role of eelgrass as nursery habitat for juvenile fish/shellfish and in sequestering carbon to ameliorate increasing atmospheric CO_2. By developing a broader understanding of the social and ecological context of sea otters in Southeast Alaska, we may be more effective in appreciating the complex role of sea otters and bringing this information into the local and regional decision making process.

Investigating the energetic cost of anthropogenic disturbance on the southern sea otter (*Enhydra lutris nereis*)

Heather E. Barrett[1], Gena Bentall[2], Tim Tinker[3], Gitte McDonald[1]

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3) Biology Department, Dalhousie University, Nova Scotia B3H 4R2, Canada

As coastal populations and tourism increase, there is an increase in human-wildlife conflicts. The impacts of these conflicts are not well understood for many coastal species, and of particular concern is the southern sea otter (*Enhydra lutris nereis*). Sea otters have high metabolic costs and are at risk of increased energetic costs due to human disturbance. To investigate the effects of human disturbance, behavioral scans were conducted over three years to record sea otter activity in response to potential disturbance stimuli at three locations in California (Monterey, Moss Landing, Morro Bay). We developed a hidden Markov model to predict the level of increased activity based on location, disturbance stimuli, and distance. We then paired previously recorded metabolic rates to the observed activity changes to calculate expected energetic cost. Our data indicate that disturbance to sea otters and consequent change in activity is location and distance specific. This activity change correlates to energetic costs that increase with disturbance stimuli proximity and frequency. The coupling of metabolics to activity change in response to a disturbance furthers our understanding of the true energetic cost to sea otters, while providing a sound scientific basis for management.

Where carnivores clash: evidence of competition—prey-shifting by brown bears during a period of sea otter recovery

Heather Coletti, Grant Hilderbrand, Daniel Monson, Joy Erlenbach, Brenda Ballachey, Benjamin Pister and Buck Mangipane

Sea otters are an important component of the northeastern Pacific nearshore ecosystem because when present, they have dramatic effects on nearshore subtidal and intertidal community structure and dynamics. However, commercial exploitation in the 18th and 19th centuries eliminated sea otters from the vast majority of their range, allowing their invertebrate prey populations to proliferate. Prior to substantial recovery of the sea otter population along the coast of Katmai National Park and Preserve within southcentral Alaska, brown bears utilized the abundant intertidal clam resources available there. However, in recent decades, the Katmai sea otter population has increased by approximately seven fold. In the early 1990's, brown bears along the Katmai coast were commonly observed foraging on clams in the intertidal. At that time, the Katmai sea otter population was just beginning its recovery and was estimated to be less than 1000 animals. By 2006 the sea otter population had grown to approximately 7000 animals and appears to have peaked or stabilized, with clams being their primary prey. Since 2006, sea otter energy recovery rates have declined suggesting the otter population is approaching carrying capacity. In contrast, brown bears monitored from 2015-2017 showed almost no sign of utilizing intertidal clam resources. Our results suggest sea otters out-competed bears for intertidal resources by reducing clam abundance (and thus the calories bears could consume per unit time) to the point where most bears switched to other resources. With sea otters restored to the ecosystem, indirect effects on the nearshore community likely include increased canopy and understory kelps, which could enhance salmon smolt rearing habitat and positively influence availability of salmon, the single most important food resource of Katmai brown bears. This work adds to a growing body of evidence for the cascading ecosystem effects of top-level carnivores and highlights interactions between top-level marine and terrestrial predators that have not been documented elsewhere.

Husbandry challenges during adaptation period of two young sea otters (*Enhydra lutris kenyoni*) at Oceanário de Lisboa

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Ana Raposo*, Aquarist, araposo@oceanario.pt
Nuno Pereira*, veterinary, npereira@oceanario.pt
Núria Baylina*, Curator, nbaylina@oceanario.pt

**Oceanário de Lisboa, Esplanada D Carlos I, 1900-005 Lisboa, Portugal.*

In March 2018, Oceanário de Lisboa received from Alaska SeaLife Center two young male sea otters, Odiak, one year old and Kasilof, 8 months old. The animals stayed in the quarantine facilities for one month. During this period a 24/7 surveillance was performed which allowed to acquire data on their behaviors and interactions, such as quality and time of grooming, time spent in and out of water, resting or playing. The body temperature was monitored using an internal temperature emitter and an external receptor, allowing to understand if the animals were making the correct temperature regulation according to their daily cycles.

The youngest otter exhibited compulsive and obsessive behavior some days after arrival and later in a second occasion. This behavior resulted in a very poor grooming, poor internal temperature control, appetite loss and rapid weight loss. In the first episode the animal was anesthetized for a more detailed examination of his condition and intubated for food intake. These two episodes may have originated due to different reasons. The first one was a lesion in the forepaw during the transport that got better one week after. The second one, was a relapse, that coincided with a significant increase of Kcal ingested due to a calculation error. This second episode stopped after 4 days when the amount of Kcal was adjusted to normal.

Rigid temperature control with rapid action, daily weight monitoring and control of the Kcal provided were considered key factors for the correct adaptation to the space and conditions and for the general welfare of the two animals. After one month in quarantine facilities, the young sea otters were stable, healthy and eating well. The introduction to the exhibition space went very well. The interaction with the resident older females was quite good, and until now no other compulsive and obsessive behavior was observed.

Long-term trends for sea otters on the Pacific Northwest coast from archeological remains and traditional knowledge: ecological and indigenous histories before the maritime fur trade

Iain McKechnie, University of Victoria and Hakai Institute
Anne K. Salomon, Simon Fraser University

The relationship between humans and sea otters, two well-documented keystone predators occupying the north Pacific rim, has spanned millennia yet their interactions over this time remain unresolved despite their profound ecological and social-cultural significance. Here we present a meta-analysis of zooarchaeological data from the Pacific Northwest Coast that pieces together existing archaeological information about the spatial and temporal variation in these keystone interactions through deep time to gain a better understanding of ecological and socio-cultural implications of these dynamics in the past, address the symptoms of sliding baselines, and ultimately inform future conservation and management strategies.

Keywords
Zooarchaeology, Marine Historical Ecology, Indigenous Conservation, North Pacific

Assessing anthropogenic risk to sea otters for reintroduction into San Francisco Bay

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Despite decades of federal and state protection, the southern sea otter (*Enhydra lutris nereis*) continues to experience sluggish population growth and has reclaimed only a fraction of its historic range. Managers of this threatened species have identified the growing need to facilitate range expansion via reintroductions in order to address the challenges facing southern sea otter recovery. San Francisco Bay has been identified as a candidate reintroduction site, but despite having historic presence in the Bay, sea otters have been absent from this ecosystem for over a century and it is unknown whether they could live in this highly urbanized estuary today. Sea otters attempting to resettle San Francisco Bay will contend with threats from a diverse array of human uses in the Bay, at a magnitude far greater than is currently experience anywhere else within their current geographic range. To address this knowledge gap, we used a spatially-explicit risk assessment framework to assess the quality and availability of sea otter habitat given exposure to multiple anthropogenic stressors. By incorporating risk into predictive habitat suitability modeling we are able to provide critical information to managers about the potential threats sea otters will face that could undermine their attempts to reoccupy their historic home range.

Georgia Aquarium facility update

Jennifer Odell

The Georgia Aquarium is currently home to 2.2 Southern Sea Otters. Since our last facility update, our Animal Training team has continued to expand the otters' behavioral repertoire, including making great progress on behavioral blood draw behaviors with all four individuals. Visitors that participate in the sea otter encounters program form a connection with the animals and learn how they can have a positive impact on the health of our oceans through small changes in their daily habits.

Investigating microplastic ingestion in sea otters through scat analysis

Jennifer Van Brocklin

The presence of microplastics in marine environments is becoming an increasing concern due to their potential impacts on marine species. As part of a master's thesis project to investigate how sea otters may be exposed to these pollutants, we will be assessing the number and type of microplastics ingested by sea otters by analyzing diet and scat samples in ex- and in-situ individuals. We will also be exploring the possible change in microplastic load sea otters have experienced over time by observing microplastic presence in archived samples.

#TeamOpenCoast or #TeamEstuary? The costs and benefits of two key sea otter habitats

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Despite traditionally being associated with kelp forest habitats, sea otters also populate soft-sediment bays, lagoons, and estuaries within their current ranges. These habitats can offer different benefits and constraints to individuals, such as prey availability and diversity, survival risks and access to resting and feeding areas. By improving our understanding of how sea otters adapt to and use these different habitats, we can better predict how sea otters will respond to potential novel environments as they expand their population range in California. We compare sea otter behavior (such as diet, forage patterns, hauling-out frequency, home range, and survival) from residents monitored in Elkhorn Slough (estuary habitat) and Monterey and Big Sur (open coast habitat) and how it may relate to environmental differences (sea surface temperature, habitat features (tidal change, depth, land access)). We found that sea otters residing in Elkhorn slough had lower diet diversity, drastically smaller home range sizes, and spent more time hauled out. Although Elkhorn Slough provided protection from sharks, calmer sea conditions, and warmer water, their mean annual survival rate did not differ significantly from open coast sea otters. Other attributes commonly associated with density dependence (time spent foraging and length of pup dependency) followed the same patterns in the estuary population as previously observed open coast habitats. Our results suggest that both habitat types can play an important role in future range expansion.

A Bayesian model of Washington sea otter population dynamics

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The northern sea otter (*Enhydra lutris kenyoni*) was extirpated from Washington State in the early 1900s and reintroduced in 1969 and 1970. After their reintroduction, counts of sea otters were collected during coastal aerial and land-based sea otter surveys from 1977 to 2017 and were used to generate indices of population size. We used a Bayesian state space modeling framework to fit a model to the survey data, as this approach easily allows for both process error (reflecting environmental stochasticity) and uncertainty arising from observation error. The model tracks abundance and demographic processes within regions of the Washington coast. We will present preliminary results from this model.

New tagging technology for sea otter research: an update on OtterNet

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Biologists from the USGS and the Monterey Bay Aquarium have teamed up with NASA engineers to develop a new tagging technology for tracking wildlife, with a specific focus on an electronic flipper tag for sea otters. Although traditional tagging via VHF and TDR implantation remains an effective way of monitoring wild sea otters, concerns about health impacts to animals and limitations of data retrieval prompted us to explore alternative methods of sea otter monitoring. We have used the latest available technology to design a tag that will collect novel and improved data, while also being more affordable and less intrusive to sea otters. The new design incorporates all hardware and electronics in an encapsulated flipper tag that does not require surgical implantation. The tag features geo-location (via GPS) and peer-to-peer networking capabilities, allowing tags on different sea otters (and eventually different species) to "talk" to each other and exchange data. The peer-to-peer approach exponentially improves data retrieval opportunities, as downloading data from a few animals provides information for the entire network. The exchange of data between tagged animals also produces fundamentally new types of information – social interactions and population connectivity – on subjects that have been difficult to study until now. Data are passively or actively downloaded to base stations using a variety of innovative platforms. The tags are currently functioning in a lab setting and soon to be tested on live captive animals, a necessary step before deployment on wild sea otters. We believe that this new "smart" flipper tag has far-reaching applications in the field of wildlife monitoring, serving to better connect researchers to their study animals, while also revealing a great deal about animal interactions and connectivity within and among populations and ecosystems.

SEA LIFE Center Birmingham

Karen Rifenbury

SEA LIFE Birmingham, U.K. will become part of the Sea Otter Community with the installation of its new Sea Otter exhibit. The display will be completed by March 2019 with hopes that the animals will arrive in early 2020. Sea life is working with the Alaska Sea Life Center where the animals have been identified and are currently being raised. We would like to give a brief overview of the project and introduce you to SEA LIFE Birmingham.

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Sea otter parasites

Kyle Shanebeck

Food webs are often more complex than biology textbook figures let on. Sea otters are charismatic animals at the centre of considerable conservation efforts. They are also keystone species in their ecosystems and play a vital role in kelp forest ecosystem structure and functioning. Potential variations in their breeding success and population dynamics following perturbations can have dramatic effects on the whole ecosystem. The only parasite that exclusively uses sea otters as a definitive host, *Corynosoma enhydri* if often dismissed as insignificant for otter and ecosystem health. We argue here that the dismissal of this widespread, prevalent and abundant parasite of sea otters is premature, and potentially negligent. Parasites are increasingly recognized as an integral part of food webs in marine ecosystems. Many species affect host behavior, influencing rates of predation and prey preference. Some parasites suppress immune response, and may increase rates of polyparasitism or secondary bacterial infection. Parasites can also affect energetics and metabolic success of hosts, a limiting factor for sea otter population success. Furthermore, little is known about how increasing ocean temperatures and climate change may influence infection levels and how this could affect sea otters and kelp forest ecosystem health.

Esophageal perforation in a southern sea otter (*Enhydra lutris nereis*)

Lauren T. Michaels, Todd Schmitt, Elsburgh Clarke, Kelsey Seitz-Herrick

SeaWorld, San Diego, California 92109

On September 19, 2016, a 4 year old female Southern sea otter (*Enhydra lutris nereis*) living at SeaWorld San Diego, became anorexic and exercise intolerant. The patient had no previous medical history, however, three weeks prior the staff observed an abrupt diet aversion to shrimp. A cursory exam was conducted at the exhibit under manual restraint. A blood sample was collected, and hematology and serum chemistry analytes were relatively unremarkable, showing a mild increase in white blood cells, mild dehydration and moderately increased muscle enzyme values. The patient was started on subcutaneous fluids, injectable broad-spectrum antibiotics and pain medication. The following day, a thorough physical exam, radiographs, ultrasound and blood sampling for fungal serology were performed under general anesthesia. On exam, the otter was noted to have good body condition, but increased respiratory effort and muffled lung sounds on auscultation. Initial thoracic radiographs revealed a severe, diffuse alveolar pattern suggestive of pneumonia. A trans-tracheal wash was performed, and the cultured sample grew a resistant *Staphylococcus epidermidis*. Fungal serology was negative. Supportive care and sensitivity-directed antibiotics were continued post-anesthesia. After a few days of treatment, the otter continued to have tachypnea after exercise, but showed mild improvement in her energy levels and appetite. On September 26, 2016, the patient began regurgitating. Follow-up radiographs, blood and gastric samples were performed and revealed mild improvement in her pulmonary pattern and static hematology and serum chemistry values. Toxoplasma testing was negative. Anti-emetics and a gastrointestinal pro-motility agent were added to her therapy. Despite mild improvement on this therapy, the patient spontaneously died 36 hours later. Necropsy revealed a small, chronic, distal, focal esophageal perforation (0.6 cm x 0.3 cm) that dissected 8 centimeters in length creating sacculation within the serosal layer. In addition, there was 1 liter of green brown fibrinous pleural fluid, as part of the diffuse pyothorax and pleuritis. It was suspected that the original insult (possible food source) had incited a partial esophageal tear creating an outpouching of the esophagus filled with purulent material. Eventually the outpouching ruptured and caused a secondary pyothorax and pleuritis resulting in the patient's ultimate respiratory failure and demise. Microbial culture of the sacculation revealed growth of *Staphylococcus lentus*. Culture of the pleural effusion was negative for bacterial growth. It was hypothesized that the culture of the pleural fluid was negative for bacteria because the patient had been treated with broad-spectrum antibiotics for almost one week prior to death.

Continued next page

Esophageal perforation in a southern sea otter (*Enhydra lutris nereis*) *continued*

Ultimately, it was believed that a piece of the patient's food, possibly shrimp, perforated through her esophagus resulting in a pyothorax and her eventual respiratory failure. When considering this case, a question is raised about what types of diets to feed sea otters under human care. Esophageal perforation and subsequent comorbidities associated with this insult should be considered in future sea otters, managed or wild, that present with similar clinical signs. This case illustrates the importance of monitoring subtle behavioral signs, like a specific food aversion, in sea otters under human care. In addition, this case serves as a teaching point for biologists, veterinarians and husbandry staff working with sea otters, that the natural crustacean diet of the Southern sea otter is not necessarily benign, and it can cause trauma to the gastrointestinal system of this species.

Conservation success, now what? Challenges of maintaining long term population surveys for a species with an expanding range

Linda Nichol

Canada's sea otter population, primarily descendants of a small number of animals (85) translocated from Alaska (1969 to 72), has continued to grow and its range expand, re-occupying historically occupied habitat. But where surveys were once easily accomplished in a period of a few days in the region where the population first established, the population now ranges over a broad area that challenges the current survey methods given the size of the area. Successful conservation, but how to maintain the population growth time series? This talk will discuss the challenges and considerations for ongoing monitoring of this conservation success story and future and emerging objectives for population surveys.

Cuddle party! The use of sea otter narratives by Pacific Coast wildlife sanctuaries to further marine conservation

Lindsey Popken, University of California, Davis

This research study examines the use of sea otter narratives by seven Pacific coast wildlife sanctuaries. Exploratory research was conducted using qualitative and quantitative data to determine how sanctuaries were using sea otter narratives, and the most frequently used platforms to deploy said narratives. The study tests the hypothesis that northern Pacific coast wildlife sanctuaries deploy more sea otter narratives than their southern counterparts. 100 posts from each sanctuary's Instagram, Facebook and Twitter feeds were classified against evaluative criteria to determine the frequency and context of the sea otter narratives deployed to the public. Interviews with wildlife sanctuaries personnel and political actors were also used in the data analysis to determine the why northern wildlife sanctuaries deploy more frequent sea otter narratives than southern sanctuaries.

The results show that that Pacific coast wildlife sanctuaries use narratives to further sea otter and ocean preservation primarily through information about oceanic degradation, humor, and aquarium information-related narratives. Narratives tend to rely on the charismatic nature of the sea otters and their contributions to marine environments, while hooking the audience into returning to the data source and wildlife sanctuary.

As anticipated, northern wildlife sanctuaries appear to use sea otter narratives more frequently than southern ones. Literature, field observations, and original interviews suggest that this is because the majority of the world's sea otters reside in the northern region. Also, northern sanctuaries reside in less densely populated regions relative to the popular tourist spots southern wildlife sanctuaries reside within. Finally, the Northern Sea Otter has experienced more voluble population loss since the 1990s, reasons of which the scientific community has yet to agree upon, suggesting that northern wildlife sanctuaries need to deploy higher rates of conservation-based posts to continue public awareness and support.

The study's findings ultimately demonstrate the value that sanctuaries can derive by utilizing a species that is admired by the general public to foster interest in environmental issues and conservation efforts. Sanctuaries can strategically deploy narratives such that this interest ultimately extends beyond the specific species and into conservation for broader ecosystems and their inhabitants.

ASL 2018 Admits

Lisa Hartman, Alaska sealife center

Riggs
November 1, 2018

Ranney
June 1, 2018

Bishop
January 1, 2018

Dixon
August 9, 2018

I will be giving a short update on the 2018 Northern sea otter admits to our program and the international move of two otters to Lisbon, Portugal.

What's going on there? Changes in directions for the Monterey Bay Aquarium sea otter program

M. Staedler, C. D'Angelo, J. Fujii, S. Hazan, K. Mayer, T. Nicholson

Over the past few years, the Monterey Bay Aquarium's Sea Otter Program has undergone changes in personnel and position responsibilities. Additionally, some changes have been made to how we facilitate moving non-releasable stranded otters to captive facilities. Our surrogacy and release/reintroduction program is taking on new dimensions and partners. Field research on wild otters, will remain in place, but at a much more reduced capacity. We still hope to work with partners on ecosystem focused scientific opportunities and conducting studies on the least known patterns of juvenile otters.

Using behavioral and physiological data to evaluate animal welfare in marine mammals: a case study on sea otters

Nicole Nicassio-Hiskey, Julie Christie, Jen DeGroot, Rob Draughon, Megan Hagedorn, Amy Hash, Renee Larison, Sara Morgan, Christina Parr, Michelle Schireman, Celess Zinda, Amy Cutting, Nadja Wielebnowski, Candace Scarlata

Oregon Zoo, Portland, Oregon

In recent years, zoos and aquariums have increased their efforts to systematically evaluate and improve animal welfare. One tool that can be used for objective assessment of physiological state is the monitoring of adrenal hormones in fecal samples. Since 2015, animal care staff at the Oregon Zoo have been collecting fecal samples from various animals for hormone analyses in our on-site endocrinology lab. The lab uses enzymeimmunoassay (EIA) techniques to track reproductive hormones like estrogen, progesterone and their metabolites, as well as adrenal hormones like cortisol, corticosterone and glucocorticoid metabolites (GMs). Temporary increases in GMs can occur in response to negative or positive events and can be used to identify acute stressors and responses to novel stimuli, such as a new enrichment item. Long-term elevations of GMs may indicate the existence of a chronic stressor, such as an on-going health issue. When paired with detailed behavior data, hormone data can be used to evaluate animal welfare, investigate responses to specific events or management decisions as well as facilitate end of life discussions. The following presentation discusses several examples in which paired hormone data and behavioral data were used to monitor animal welfare in 2.1 southern sea otters (*Enhydra lutris*).

Longitudinal assessment of domoic acid exposure and relative hazard of death due to cardiomyopathy in southern sea otters (*Enhydra lutris nereis*)

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Southern sea otters (*Enhydra lutris nereis*) are a threatened species that has struggled to recover and expand its range in California, despite active management. Blooms of the marine diatom *Pseudo-nitzschia* often produce domoic acid, a potent neurotoxin that is an important cause of mortality among marine mammals and seabirds along the Pacific Coast of North America. Domoic acid toxicosis and cardiomyopathy have recently been identified as two important causes of mortality among sea otters, and previous research has linked domoic acid exposure to development of cardiomyopathy in otters. Southern sea otters have been systematically necropsied for many years, providing a unique opportunity to investigate patterns of mortality through time. In addition, long-term telemetry-based field studies of living sea otters permit a detailed assessment of demographic, behavioral, and environmental characteristics through direct observation and the use of radio-transmitter tags. This longitudinal study includes sea otters that were tagged and monitored over much of their lives and examined in detail after death. Telemetry-based field studies and necropsies provided data on age and sex-specific survival, diet assessment, reproduction, movement patterns, pathologic findings, postmortem diagnostic tests, and cause of death determination. Additionally, we incorporated temporally and spatially explicit domoic acid data series from environmental monitoring sources. We used a time-dependent, extended Cox regression model to estimate the survival experience of sea otters with different prey preferences and exposure to domoic acid and to compare their respective hazards of dying from cardiomyopathy, conditional on demographic, behavioral, and environmental covariates. The goal of this project is to combine data from necropsies with data from intensively monitored free-ranging sea otters to unravel the complex relationship between cardiomyopathy and domoic acid exposure. Our work is ongoing and we aim to incorporate spatially-explicit health threats, like domoic acid intoxication and cardiomyopathy, into a larger demographic model that can be used to project future population dynamics. We intend for this analytical modeling framework to optimize science-driven management actions for sea otter population recovery.

Uterine leiomyoma, cystic endometrial hyperplasia and endometriosis in a northern sea otter (*Enhydra lutris lutris*)

Megan M. Strobel, [1] ***Stephen A. Raverty,*** [2] ***Sion N. Cahoon,*** [1] ***Gabrielle N. Beer,*** [1] ***Amanda E. Gawor,*** [1] ***Martin Haulena*** [1]

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One 14-year-old female Northern sea otter (*Enhydra lutris lutris*) from the Vancouver Aquarium collection presented with non-painful caudal abdominal swelling in March 2018. Initial bloodwork and ultrasound were suggestive of early-term pregnancy. While the animal continued to behave clinically normal, monthly bloodwork monitoring revealed persistent elevations in progesterone. Ultrasonographic monitoring was consistent with mild fluid accumulation within the uterus and no evidence of progression in fetal development. Seven months later, a round soft tissue structure, measuring approximately 3-4 cm, surrounded by fluid within the uterus was noted on radiographs and ultrasound. Ovariohysterectomy performed in December 2018 revealed two firm, fibrous masses measuring approximately 4.5cm and 2.5cm within the right and left uterine horns, respectively. Histopathology revealed nonencapsulated moderately cellular nodules of large fusiform cells with variably distinct cell membranes, consistent with leiomyoma with a mitotic index of 0-1/10hpf. Marked cystic endometrial hyperplasia and endometriosis were also noted within the uterus. Subsequent staging revealed no abnormalities in the lungs, lymph nodes, liver or spleen. Leiomyoma, a benign soft tissue tumor, was previously described in two Northern sea otters (*Enhydra lutris*) from Alaska post-mortem and in three sea otters at the Shedd Aquarium.[1,2] In humans, progesterone and estrogen receptors have been documented in 70-80% of these tumors, with the hormones encouraging growth.[3] In humans, it is suspected that cases of leiomyosarcoma result from malignant transformation of leiomyomas.[3] Cystic endometrial hyperplasia was noted in one otter at Shedd with leiomyoma, however has not been otherwise reported.[2] Cystic endometrial hyperplasia, along with endometriosis, likely contributed to discomfort and reproductive failure in this animal.

Acknowledgments

The co-authors would like to thank the marine mammal department at the Vancouver Aquarium for their hard work and support throughout diagnosis and treatment of this animal. Thanks to Dr. Sophie Dennison and Dr. Marina Ivančić for radiographic interpretation and to the staff at the Animal Health Centre and IDEXX for histopathology processing and interpretation.

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The dead do tell tales! Investigating southern sea otter (*Enhydra lutris nereis*) mortality patterns (1998–2012)

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The most recent comprehensive review of southern sea otter (SSO: *Enhydra lutris neries*) mortality patterns was completed >15 years ago[2], and was limited to 105 cases. To address this knowledge gap, our multi-agency team compiled data from 560 SSO necropsies spanning 15 years. Enrolled animals were minimally decomposed, with detailed necropsy performed during 1998-2012, including all eligible subadult (1-4 years), adult (4-10 years), or aged adult (>10 years) SSO of either sex; younger animals were excluded due to more limited examination by veterinary pathologists, and lower probability of guiding key conservation decisions. Our sample population included all opportunistically collected animals within the SSO range in California, and all tagged otters that fit the above selection criteria. The primary and contributing cause(s) of death were determined based on gross lesions, histopathology and diagnostic tests, including systematic serology and biochemical testing. Standardized coding was established to distinguish between primary or contributing cause(s) of death, and sequelae such as secondary bacterial infection. In addition to updating collective knowledge regarding "classical" causes of SSO death, such as white shark (*Carcharodon carcharias*) predation[6], protozoal infection and *Profilicollis* sp.-associated acanthocephalan peritonitis[2,4], we also studied less well-characterized processes, such as domoic acid (DA) intoxication, cardiomyopathy[3] and end-lactation syndrome (ELS)[1,5] that could be impacting SSO population recovery. Spatial scan statistics and multivariate models were used to identify high or low-risk coastal locations for common diseases, and potential connections between common causes of SSO death. Our models also highlighted associations between risk of presenting with specific health conditions and SSO sex, age, stranding date, stranding season, stranding year, and other factors. Shark bite was the most common primary cause of death, followed by acanthocephalan peritonitis, probable DA intoxication, cardiomyopathy, ELS, and primary bacterial infection. When the primary and top three contributing cause(s) of mortality were pooled, the most common cause(s) of SSO death were cardiomyopathy, gastrointestinal erosions/melena, shark bite, protozoal infection, probable DA intoxication, possible DA intoxication, ELS, emaciation, and primary bacterial infection. Significant spatial, temporal, or space-time clustering was noted for several common causes of death, including shark bite, acanthocephalan peritonitis, protozoal disease, ELS, cardiomyopathy and coccidioidomycosis. Shark bite was significantly more common as a cause of death during later years, in subadults stranding in good nutritional condition, and for SSO stranding from August through January. Acanthocephalan peritonitis was

Continued next page

The dead do tell tales! Investigating southern sea otter (*Enhydra lutris nereis*) mortality patterns (1998–2012) *continued*

significantly more common in emaciated subadults, and otters stranding near Moss Landing from 2002 through 2007. Although SSO stranding during the late wet and early dry season were nearly 1.6 times more likely to strand with acanthocephalan peritonitis, this finding was not statistically significant. Bacterial infections as sequelae were important contributors to death from shark bite and acanthocephalan peritonitis.

Acknowledgements

We gratefully acknowledge assistance from many contributors, including Patricia Conrad, Tracey Goldstein, Walter Boyce, Alyssa Capuano, Stori Oates, Jonna Mazet, Mike Ziccardi, Matthew Blake, Kirsten Gilardi, Linda Lowenstein, Lavonne Hull, Woutrina Miller, Katie Greenwald, Angie Reed, Jack Ames, Dave Jessup, Jessica Kunz, Ben Shaw, Mike Sowby, Eva Berberich, Sharon Toy-Choutka, Gina Bartlett, Luz deWit, Christen Bechert, Sara Huckabone, Sarah Chinn, Raphe Kudela, Brian Hatfield, Joe Tomoleoni, Ben Weitzman, Mike Murray, Michelle Staedler, Karl Mayer, Andy Johnson, Marissa Young, Karen Worcester, David Paradies, Mary Adams, Lilian Carswell Frances Gulland, Padraig Duignan, Amanda Foss, Mark Aubel, Eric Delwart, Juliana Siqueira, Terry Ng, Linlin Li, Xutao Deng, Katie Colegrove, Kathi Lefebvre, Kathy Burek, the UCD VMTH histology and microbiology staff, and CAHFS staff for their outstanding diagnostic work. Our team would also like to express their sincere appreciation to the citizens of California for making this work possible through contributions to the California Sea Otter Fund (Sea Otter Tax Checkoff) through the California State Coastal Conservancy, and the California Department of Fish and Wildlife, Office of Spill Prevention and Response.

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Investigating the relationship between genetics and disease outcome in necropsied southern sea otters (*Enhydra lutris nereis*)

Authors

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Southern sea otter (SSO-*Enhydra lutris nereis*) population recovery is impacted by a variety of factors including predation, biotoxin exposure, infectious disease, oil spills, habitat degradation, and resource limitation. Factors underlying the high susceptibility of SSO to death from bacterial, protozoan and acanthocephalan infections remains poorly characterized. In addition, common pathologies such SSO death due to cardiomyopathy could have a multifactorial basis that includes a genetic component. Our core objective is to investigate the relationship between genetic attributes and disease outcome in a large sample of necropsied SSO.
We hypothesize that 1) Sea otters that are more closely related are likely to share similar disease outcomes and 2) Sea otters that die due to some common processes possess lower genetic diversity, when compared to the larger SSO population. To investigate these hypotheses, we will combine 15 years of detailed SSO necropsy data with existing microsatellite genetic data for 360 individuals. In the first year of the project, we will use 37 microsatellite loci to construct a pedigree and calculate pairwise relatedness and internal relatedness among sea otters. In the second year, we will incorporate data on pathogen exposure and key case(s) of death onto the pedigree and pairwise relatedness matrices, to determine if certain etiologies are associated with specific family lines or relatedness categories. Our analyses will incorporate supplementary data on environmental, behavioral and density-dependent co-variates, to control for the confounding influences of these factors. This work is part of a larger project which will involve sequencing across the entire SSO genome to test for associations among variation in the sea otter genome, in relation to pathogen susceptibility and disease outcome. Our study will inform conservation management decisions to optimize sea otter population health and facilitate population recovery.

Sea otter diet composition with respect to recolonization, demographic, and seasonal patterns in southern southeast Alaska

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Until translocation efforts in the 1960s, sea otters (*Enhydra lutris*) were absent from Southeast Alaska due to extirpation from the fur trade in the 18th and 19th centuries. About 400 sea otters were reintroduced to six Southeast Alaska locations including two sites near Prince of Wales (POW) Island in southern Southeast Alaska. The most recent US Fish and Wildlife Service population count, completed in 2012, estimates that 25,000 sea otters inhabit Southeast Alaska. Previous foraging studies throughout the sea otter range have shown that sea otters will reduce invertebrate prey biomass when recolonizing an area. Foraging data were collected around the west coast of POW to determine diet composition. Sites were selected according to time-since-recolonization. A total of 3,372 foraging dives were recorded during May-August 2018. Across all sites, sea otter diet was overwhelmingly composed of clams (68% of total biomass). Sea otter diets were analyzed with respect to age, sex, seasonality, and inhabitance duration. The next step in this study includes macronutrient analysis and $^{13}C/^{15}N$ stable isotope analysis of sea otter prey to understand how Southeast Alaska sea otters meet their energetic needs compared to other sea otter populations and gain a better understanding of seasonal diet shifts. The results of this study will aid in future management of shellfisheries, subsistence hunting, and co-management of a protected species by providing quantitative data for stakeholders. This work is a part of a large-scale project examining how the recovery of sea otters structures nearshore marine ecosystems, provides ecosystem services, and affects community sustainability.

Reproductive physiology and energetics of sea otters

Authors: Thometz, N.M., Kendall, T.L., Richter, B.R., Williams, T.M.

Superimposed on inherently high baseline metabolic demands, the additional energetic requirements of reproduction can push female sea otters beyond physiological limits. Recent research has identified reproduction as a major contributing factor to over half of adult female mortality cases in California. Given the importance of reproduction to species recovery and population persistence, we are examining the reproductive physiology of sea otters to better understand individual patterns, overall energetic costs, and resulting population level consequences. We are working with wild female sea otters in a captive setting to track longitudinal changes in metabolism associated with reproduction .As part of this ongoing project, we are measuring the resting metabolic rate (RMR) of reproductive females across gestation, lactation, and post-weaning periods. Data from four female sea otters suggests that RMR declines during the last months of gestation. These preliminary data agree with published data from wild sea otters that revealed a unique decline in core body temperature over the last 3 months of gestation. This unique physiological change may facilitate increased rates of fat deposition in preparation for the energetically taxing lactation period. Metabolic data collected from two female sea otters indicate that RMR progressively increases during lactation, reaches a peak at 3-4 months postpartum, and remains elevated until weaning. This metabolic pattern conforms more closely to patterns observed in lactating terrestrial mammals rather than other marine mammals, which exhibit little to no change in baseline metabolism during lactation. The cost of reproduction in the smallest marine mammal is exceptional and is likely a major driver in the high rates of mortality observed at the end of lactation for this species.

Future directions in sea otter research and management

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The conservation and management of sea otters has benefited from a dedicated research effort over the past 60 years enabling this species to recover from a few thousand in the early 20th century to about 150,000 today. Continued research to allow full, pre-exploitation recovery and restoration of nearshore ecosystems should focus on at least seven key challenges: 1) Defining sea otter populations at smaller spatial scales that reflect this species' life history and dispersal patterns; 2) Understanding factors that regulate sea otter population density with a focus on index sites that are representative of the variety of littoral habitats occupied by sea otters around the North Pacific Rim; 3) Quantifying the effects of sea otters on the littoral community with a focus on how food availability limits population and ecosystem recovery and on predicting the effect of sea otter reoccupation on commercially valuable invertebrates; 4) Making sea otter monitoring programs comparable across geo-political boundaries through international collaboration to optimize survey efforts both spatially and temporally and to determine the cause of changes in sea otter demographics; 5) Evaluating the conservation benefits of sea otter reintroductions into historical habitat; 6) Assessing the socioeconomic costs and benefits of sea otter range expansion to anticipate and mitigate conflicts; 7) Recognizing in conservation and management plans that sea otters can be significantly affected by higher level predators in some circumstances. Many of these challenges will require new tools including the next generation geolocation tag technology that will allow assessments of long-range movements, dispersal and gene flow in various populations.

Keywords

Sea otter, population, density, littoral, monitoring, translocation, fisheries, predation

The Elakha Alliance: seeking to restore sea otters to Oregon

Robert Bailey, Board President, Elakha Alliance

The Elakha Alliance, originally convened as an informal organization in the late 1990s, has been reformed as a non-profit organization with a mission to restore sea otters to the Oregon coast. The Alliance has begun a variety of activities in pursuit of its mission, including discussions with state and federal agencies and other partner organizations and a day-long sea otter status of knowledge symposium in October 2018 for stakeholders, agencies, and partners. The Alliance is currently developing a strategic plan to guide its work with external partners, is investigating the scope and direction of a feasibility study to guide decision-making about restoring sea otters to the Oregon coast, and is discussing its mission with potential funders. The Alliance is interested in structuring its mission to reflect and benefit the conservation of sea otter populations along the West Coast and welcomes discussions among the larger sea otter community as to how best to do so. The Alliance may be reached at Elakha.Alliance@gmail.com.

Anatomy of the sense of touch in sea otters

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A combination of approaches can be used to interpret underwater foraging behavior of sea otters. Previous research in our laboratory has focused primarily on behavioral assessments of sensory abilities that sea otters likely use to detect and acquire prey. For example, we have worked cooperatively with trained otters to learn about texture discrimination using touch in air and under water. Our understanding of sensory biology in this species can be supplemented through fine scale histological analyses of sensory tissue. Here, we provide results from our recent efforts to link skin structure and touch function using anatomical approaches. We obtained freshly harvested hairless skin samples from the paws, nose, lips, and flipper pads of euthanized sea otters (n=4) through collaboration with the Monterey Bay Aquarium. After fixing the tissues in 10% neutral buffered formalin and processing them for histochemical staining with H&E, we imaged each tissue sample with light microscopy. In addition to gross descriptions of skin morphology, we report density of multiple mechanoreceptor types (including Pacinian corpuscles, Merkel cells, Meissner corpuscles, and unidentified lamellar corpuscles) responsible for different touch sensations. We compare these data across skin structures and within paw regions (digit pads, palmar pads, carpal pads) to test the hypothesis that different structures contribute to different tactile functions of skin regions in sea otters.

Sea otter genetics update: diversity, population structure and taxonomy

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Sea otters, *Enhydra lutris*, were once abundant along the nearshore areas of the north Pacific Rim from northern Japan to Baja California, Mexico. Starting in 1741 the Pacific maritime fur trade eliminated sea otter populations throughout nearly all of their range and by 1910 resulted in 13 small scattered populations, totaling less than 1% of their original abundance. Previous work found lower genetic diversity in sea otters sampled in the early 1990s compared to pre-fur trade samples. Sea otter populations were re-sampled between 2008-2011 throughout much of their range and analyzed using 20 microsatellite markers. Here we report genetic diversity and population structure compared to samples collected 20 years earlier. Genetic diversity was found to increase in most sampled locations but particularly in those founded by translocations founded by more than one population and those experiencing immigration from adjacent groups. We also investigated taxonomic relationships between populations. There are currently three recognized sea otter subspecies based on skull morphology: Russian (*E.l. lutris*), Northern (*E.l. kenyoni*), and Southern (*E.l. nereis*). Microsatellite and the mitochondrial DNA D loop variability suggest there may be more than three taxonomically distinct populations in the northern end of the range.

SeaWorld facility update

S. Hill

In October 2018, we introduced fish (Halfmoons, Opaleyes), sea urchins and lobsters to our southern sea otter exhibit. After several trials and useful strategies, the four sea otters and fish now coexist.

Our team has made it a focus to enhance our guests' sea otter experience and to utilize social media.

Our behind the scenes setting provides the guests closer proximity to the sea otters while enhancing dialogue with the trainers.

This environment plays a significant role in helping to convey the most current conservation messages concerning the wild population of the southern sea otters.

These programs, encounters and experiences will be highlighted and discussed.

Revisiting the role of southern sea otters in California kelp forests

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The role of sea otters as a keystone predator in kelp forest ecosystems has often been described, but recent evidence suggests that their impacts on prey populations may be mediated by the presence or absence of other predators. Between 2013 and 2015, several species of sea stars experienced widespread declines (from California and Alaska) due to viral disease. This wasting disease caused local extinctions of the predatory sea star *Pycnopodia helianthoides*: around the same time, urchin populations increased sharply in central California (possibly in response to the loss of *Pycnopodia*) leading to reductions in kelp and the emergence of urchin barrens. This massive perturbation – the wholescale removal of one predator – provided an "opportunistic experiment", which we capitalized on to evaluate the possible interactive role of sea otters and sea stars in controlling urchins. A second objective was to investigate how individual diet specialization in sea otters might mediate their response to increased urchin abundance. In June of 2016, twenty-six otters were tagged and instrumented with VHF radio transmitters and time depth recorders and have been monitored daily to collect observational data on survival, reproduction, habitat use, diet and foraging behavior. We compare results to data collected in previous studies along the Monterey Peninsula, to determine whether and how sea otters have altered their behavior in response to the shift in prey dynamics. Our study is combined with scuba-based experiments to measure urchin mortality rates under different predator regimes, and to test how urchin quality affects likelihood of selection by sea otter predators. Using the combined data, we will test two hypotheses: 1) sea otters and *Pycnopodia* play complementary roles in controlling herbivores, and 2) adaptive responses by sea otters can buffer the system from the loss of sea stars. We present preliminary results from the first 2.5 years of the study.

Using noninvasive ageing metrics as a tool for sea otter conservation and recovery

Authors: Teri Nicholson, Karl Mayer, Michelle Staedler, Mike Murray, Marissa Young, Jess Fujii, Tyler Gagne, Joseph Tomoleoni, Kyle Van Houtan

Reliable and noninvasive ageing metrics are an important conservation tool, especially when managing California sea otters. Ideally, metrics such as tooth eruption and decay timelines provide age-specific information necessary to calculate individual growth curves, predict gestation time and age at maturity, and identify vulnerable life-stages to mitigate potential threats to survival or range expansion. Defining these metrics requires examination of known-aged individuals, which is challenging when sampling only from the wild population. During wild sea otter studies, observers have traditionally estimated age using a combination of relative metrics, such as tooth condition, grizzle, and body length, which may be biased by several factors, including diet, resource availability, and genetic variability. Our solution is to incorporate observations from rehabilitation programs, or zoos and aquaria, where metrics may be repeatedly gathered from known-aged animals to boost sample size, reliably quantify age-specific measurements, and explore accuracy of metric types. As a first effort, we combine more than three decades of physical examination data from the Monterey Bay Aquarium Sea Otter program with California field studies to demonstrate feasibility of using noninvasive tooth eruption and decay schedules for ageing sea otters. These ageing metrics enabled us to reasonably estimate sea otter gestation time (t_0) and asymptotic average length (L_∞) by fitting von Bertalanffy growth functions to both age-specific length and girth data under different resource regimes. We also explore using x-rays of long bone growth plates to improve age estimation of sea otters between juvenile and adult stages. These tools may prove crucial for monitoring population structure, and age-specific reproduction and survival, which could be used to assess management strategies implemented to ensure sea otter recovery throughout California.

Predicting habitat-specific carrying capacity (*K*) and incorporating multiple data types into an integrative population model (IPM) to support sea otter management

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The past 20 years have seen enormous advances in our understanding of sea otter biology and ecology, together with insights into specific threats to sea otter recovery, including infectious disease, resource limitation and predation mortality. While southern sea otters have gradually increased in abundance to the threshold where de-listing (under the U.S. Endangered Species Act) may be considered, the current distribution represents only a fraction of the historic distribution and range expansion has stalled, apparently as a result of ongoing threats. Resource managers face two general challenges: 1) how can we predict the optimum sustainable population (OSP) for southern sea otters as a realistic target for management, accounting for spatial variation in habitat quality and localized carrying capacity; and 2) what specific factors and threats are most important in terms of limiting recovery to OSP in different regions (or, as a corollary, what management actions will have the greatest effect on recovery)? **We present a habitat-based estimate of carrying capacity (*K*) for southern sea otters. We then combine spatially-varying K estimates with a comprehensive array of available data sets to produce an Integrative Population Model, or IPM, that can help address emerging conservation challenges. We briefly explain the models, and then provide a demonstration of the IPM in action.**

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Sea otter recolonization associated with regional increase in kelp forest canopy

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Giant kelp (*Macrocystis pyrifera*) is a canopy forming foundation species that creates dense forests along shallow rocky reefs and provides energy and structure for a vibrant ecosystem. Sea otters (*Enhydra lutris*) are a keystone predator and serve as an important link in a trophic cascade by reducing herbivore pressure. Sea otters were reintroduced to SE Alaska and began to colonize Sitka Sound in the late-1970's. There is anecdotal evidence of increased giant kelp in the sound in recent decades, following the collapse of the red urchin (*Mesocentrotus franciscanus*) fishery, an important kelp herbivore. To investigate the potential role otters played in this regional expansion of giant kelp, we used Landsat satellite imagery to construct a time series (1984–2018) of canopy biomass in both Sitka and Monterey, CA, where otters have had a prolonged presence. Sitka showed a significant positive increase in annual maximum kelp biomass while Monterey showed no significant trend. In Sitka there were increases in kelp area added concurrent with increases in otters, while Monterey showed little increase in new kelp area. It appears that increased otter predation on kelp herbivores in Sitka induced an ecosystem state shift to canopy forming kelps. We demonstrate a non-linear functional response between otter abundance and giant kelp canopy cover, with rapid but asymptotic increases occurring soon after otter recolonization. Our findings establish a foundation for large-scale study of the spatial patterns of kelp forest state shifts and sea otter recolonizations across SE Alaska.

Validation of an animal-side serum amyloid A ELISA for the evaluation of systemic inflammation in sea otters (*Enhydra lutris*)

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The United States is home to two subspecies of sea otter: southern sea otters (*Enhydra lutris nereis*), which inhabit the nearshore waters off California, and northern sea otters (*Enhydra lutris kenyoni*), which inhabit waters off the state of Washington and the entire southern coast of Alaska from the southeastern panhandle to the westernmost point of the Aleutian chain. While population numbers have rebounded in the past decades, otters still face significant threats (e.g., boat strike, disease) and the southwestern Alaskan stock of northern sea otter is currently listed as threatened under the International Union for Conservation of Nature (IUCN) guidelines (USFWS 2014; Doroff and Burdin 2015).

Otters strand for a variety of reasons which need to be differentiated for treatment. Major causes in Alaska include dependent pups found in absence of an adult female and mature animals battling infectious diseases, often a Streptococcus sp. Clinical signs exhibited by stranded otters may be generalized and while blood analysis may be consistent with a serious infection, hematology and clinical chemistry results may be equivocal. Systemic Streptococcal infection leads to various organ derangements based on the site of infection. Blood cultures often confirm bacteremia but results take 5-7 days or longer, especially in remote locations. Meanwhile, intensive care is required, which is time consuming, depletes funds, and may be painful to the patient; often with death or euthanasia prior to availability of microbiology results. An additional, point-of-care, diagnostic test to confirm serious, systemic inflammatory illness at admit would assist in a speedier, more informed decision to proceed with rehabilitation or, if it is the best course of action, humane euthanasia.

Serum amyloid A (SAA) is a major acute phase protein in many species that rapidly increases 2 to1000 fold in response to inflammatory stimuli. Acute phase response (APR) proteins are used as screening diagnostics in domestic and livestock species because APR proteins are sensitive measures of internal inflammation and infection. It is likely that APR proteins could be a valuable tool in the diagnosis of inflammatory disease in otters as they are in cattle and other domestic animals as well as other marine mammals such as manatee. (Harr et al., 2006) A previous evaluation in domestic ferrets (Mustela putorius furo) revealed increased SAA concentration in diseased ferrets, though the disease category was incompletely described, and reported a reference interval of trace to 34 mg/L. (Ravich et al., 2015)

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Validation of an animal-side serum amyloid A ELISA for the evaluation of systemic inflammation in sea otters (*Enhydra lutris*) *continued*

This study utilized a competitive field ELISA (Equichek, Accuplex Diagnostics, Kildare, Ireland) that require 10uL of whole blood, plasma, or serum. Results are semi-quantitative line estimates for different concentrations of SAA, one to four lines representing >200 mg/L, 75-200 mg/L, 30-75 mg/L, and <30 mg/L respectively. Cross reactivity was confirmed with 5 samples from animals with known severe inflammatory disease. Precision analysis was completed by running the same sample 2-5 times on separate ELISA kits using whole blood and/or serum samples from 10 different animals. All replicates provided identical results. A brief accuracy comparison was performed with a human SAA assay (Eiken, Tokyo, Japan) and all results binned adequately. A total of 71 samples from 49 juvenile to adult, male and female sea otters representing 34 "normal" and 37 "abnormal" samples were analyzed. Normal and abnormal categories were assigned by the clinician based on history, physical exam, and final disposition. Based on initial evaluation of samples from animals categorized as healthy, evaluators assessed 4 lines as a decision threshold (result within normal limits). In this population, this assay produced an 89% diagnostic specificity and 85% diagnostic sensitivity. Positive and negative predictive value was 87 and 88% respectively. The positive likelihood ratio indicates that an animal with a positive test is 6 times as likely to have significant inflammatory disease as a negative test.

Therapeutic and prognostic implications will be discussed during the session.

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Developing a blueprint for sea otter restoration in the state of Oregon: making a case for collaborative and place-based adaptive strategies

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Differing values among stakeholders can impede the effectiveness of marine mammal restoration efforts. Community dimensions, as applied to the restoration of sea otter, and associated issues with human-marine mammal conflict, must therefore evolve beyond the traditional focus on habitat availability, prey abundance, population viability, and predator removal methodologies in response to perceptions of conflict and/or reported conflict incidents.

However, during the process of developing management plans for the restoration of marine wildlife and sustainable human-marine mammal conflict resolution, broad stakeholder engagement is frequently undefined and may lack novel, place-based coalitions. In addition, conflict mitigation plans often exclude the ability to adjust to evolving socio-economic perspectives, needs, and potential community and agency transformation.

To address these shortcomings, the addition of socio-economic elements, through collaborative and adaptive strategies, has the potential to lead to a blueprint that not only facilitates continuing dialogue between biologists, community stakeholders, and wildlife managers, but can also serve as essential components of sustainable marine mammal restoration efforts.

At this time, there is not a state or federal sea otter management plan in place that specifically addresses restoration efforts in Oregon, or a comprehensive conflict resolution plan that mitigates human-marine mammal conflict along the coasts of Oregon and Washington. In Oregon, the importance of such plans is evident by the lack of a resident population of sea otters, the literature that supports the standing of sea otter as a keystone species relative to their critical importance to the health and stability of the nearshore marine ecosystem, and by the related example of the continued escalation in conflict between sea lions/seals, commercial fisheries, and restoration efforts for endangered salmonids in the states of Oregon and Washington.

Topics of consideration include:

1. Utilizing a holistic and integrated approach, can key principles of ecosystem-based management play a significant role in the restoration of sea otter in the state of Oregon?
2. Are collaborative and place-based adaptive strategies an effective means to managing human-marine mammal conflict in the states of Oregon and Washington?
3. What factors limit and/or support the implementation of collaborative and place-based adaptive strategies in marine mammal management in the states of Oregon and Washington?

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Developing a blueprint for sea otter restoration in the state of Oregon: making a case for collaborative and place-based adaptive strategies *continued*

Biographical notes

VALERIE STEPHAN-LEBOEUF began working with wildlife as a zookeeper. She spent ten years as a wildlife rehabilitator, during which time she also designed and implemented an effective and humane population control and human-wildlife conflict resolution program in response to beavers living within an urban area. She continues to advocate for wildlife, including her work as an educator and presenter for The Animals' Trust and as an educator and facilitator of human-wildlife conflict resolution. She has presented at professional conferences in the United States, Canada, and Greece, has a master's degree in education with an emphasis on environmental education, and a Master of Science in environmental science. She is a doctoral candidate in environmental science with the University of Idaho, USA, researching the restoration of sea otters in the state of Oregon, and is a current Oregon Sea Grant Fellow.

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Velocity of community shift and alternative kelp forest states: how long-term subtidal monitoring can focus dialogue surrounding nearshore conservation and management

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Since 1980 biologists with the US Geological Survey, UC Santa Cruz, and the US Fish and Wildlife Service have biannually sampled six monitoring stations in the nearshore subtidal around San Nicolas Island (SNI), CA. This ongoing program has captured decadal periodicity (e.g., ENSO events, PDO), and the permanent sampling locations allow for a spatially explicit examination of how temporal dynamics vary around the island. However, the timeseries is more than just a record of the nearshore subtidal around SNI—it is a test of both our (1) empirical conceptualizations of how kelp forest communities are structured, and (2) our theoretical predictions for how ecosystems with one or more stable attractor change over time. Here we examine broad patterns of temporal dynamics, and we relate those kelp forest community dynamics to the physical substrate comprising the permanent sampling locations. To test predictions of dynamical systems theory, we relate velocities of community shift to the underlying Potential landscape comprising each transect. We present evidence of three alternative kelp forest states—deforested urchin barrens, a mixture of urchins and macroalgae, and macroalgae exclusive—and we examine how the stability and resilience of these respective states vary given local and broad scale factors, including the presence of the translocated sea otter population. By exploring how temporal community dynamics are modified by local factors, we have built a framework to think about the selection of nearshore subtidal locations that receive conservation and management attention. Specifically, we can focus attention towards nearshore subtidal locations that have greatest potential for exhibiting desired community structure, i.e., locations with the greatest potential for exhibiting stable macroalgae populations through time.

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