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**SCIENTIFIC PROGRAM FULL ABSTRACTS**

FACTORS ASSOCIATED WITH MARBLED MURRELET  
(*BRACHYRAMPHUS MARMORATUS*) NESTING  
SUCCESS IN WESTERN OREGON

Lindsay J. Adrean  
([lindsay.adrean@oregonstate.edu](mailto:lindsay.adrean@oregonstate.edu))<sup>1\*</sup>, S. Kim Nelson  
([kim.nelson@oregonstate.edu](mailto:kim.nelson@oregonstate.edu))<sup>2</sup>, Marie-Sophie Garcia-  
Heras ([ms.garciaheras@oregonstate.edu](mailto:ms.garciaheras@oregonstate.edu))<sup>3</sup>, Daniel D.  
Roby ([daniel.roby@oregonstate.edu](mailto:daniel.roby@oregonstate.edu))<sup>3</sup>, Matthew G.  
Betts ([matt.betts@oregonstate.edu](mailto:matt.betts@oregonstate.edu))<sup>4</sup>, and James W.  
Rivers ([jim.rivers@oregonstate.edu](mailto:jim.rivers@oregonstate.edu))<sup>1</sup>

<sup>1</sup>Department of Forest Ecosystems and Society,  
Oregon State University, Corvallis, Oregon, USA

<sup>2</sup>Department of Fisheries and Wildlife, Oregon State  
University, Corvallis, Oregon, USA

<sup>3</sup>Oregon Cooperative Fish and Wildlife Research Unit,  
Department of Fisheries and Wildlife, Oregon State  
University, Corvallis, Oregon, USA

<sup>4</sup>Forest Biodiversity Network, Department of Forest  
Ecosystems and Society, Oregon State University,  
Corvallis, Oregon, USA

Management of habitat in Oregon's coastal forests for the threatened Marbled Murrelet (*Brachyramphus marmoratus*) requires information on nesting success and on factors that may affect nesting outcome. The cryptic breeding behavior of this species is a challenge for nest searching; prior to 2018, just 30 active nests had been found in Oregon, preventing precise conclusions on the factors responsible for successful reproduction. During the April–September breeding seasons in 2017 and 2018, we used a combination of VHF telemetry and visual dawn surveys to track 137 murrelets radio-tagged at sea and identify their nest sites in the Oregon Coast Range. We collected blood samples to assess the physiological condition of the birds, and used nest cameras and automated telemetry systems to monitor nesting activities. In contrast to 2017, when no inland movements by tagged birds were detected, we detected inland movements of 12 murrelets tagged in 2018 (16%) and 8 nest sites were identified. Nest initiation dates ranged from May 2 to July 11, extending much later into the summer than expected. All nests were located on federal lands, but the positions within mature forest patches varied. Of the 7 active nests monitored, 3 fledged young. With just this small sample of nests, we confirmed a previously undocumented nest predator, documented a new nest tree species for Oregon, and increased the number of active nests with known fates in the state by 20%. Subsequent years of this long-term study will allow for robust analysis of physiological and environmental factors affecting nest success and provide valuable information to land managers.

A CONSERVATION ROADMAP FOR OCEAN  
WANDERERS

Karel Allard ([karel.allard@canada.ca](mailto:karel.allard@canada.ca))<sup>1</sup> and Carina  
Gjerdrum ([carina.gjerdrum@canada.ca](mailto:carina.gjerdrum@canada.ca))<sup>2</sup>

<sup>1</sup>Environment Canada, Canadian Wildlife Service, 17  
Waterfowl Lane, Sackville, NB E4L 4N1 Canada;

<sup>2</sup>Environment Canada, Canadian Wildlife Service,  
Dartmouth, NS

Procellariiformes wander over extensive expanses of ocean, regularly spanning geo-political boundaries, and facing different anthropogenic threats along the way. Today, the International Union for the Conservation of Nature (IUCN) considers this bird group to be the most threatened on the planet. Conservation strategies focus on improving knowledge and addressing threats, on breeding colonies and at sea. However well designed and collaboratively developed, these strategies can remain species-centered and structurally disjoint from broader conservation work and related opportunities.

Our primary goal is to share an increasingly adopted, comprehensive approach to overcoming barriers to informing and integrating conservation efforts across species, mandates, and jurisdictions, toward improving overall conservation outcomes. Through coordinated questionnaires, online and in-person workshops, interested parties will develop a comprehensive *Situation Analysis* for Procellariiformes, following the steps outlined within the *Open Standards for the Practice of Conservation*. Outputs will include transferable guidance and decision-support to enhance partner efficiency and effectiveness in implementation of new and ongoing work, with clear avenues for connecting Procellariiforme projects to broader conservation initiatives.

Using common language, common metrics and a common framework, we propose to enhance efficient development and implementation of conservation strategies, with an emphasis on monitoring to demonstrate effectiveness. International partners, including the World Wildlife Fund, IUCN, Nature Conservancies, and more recently government agency managers, planners and conservation practitioners, have recognized the benefits of accessible and standardized conservation roadmaps, as these can present needed context, while enhancing communication, scalability, transferability, and overall legitimacy of efforts.

POPULATION GENETICS OF THE BAND-RUMPED  
STORM PETREL (*OCEANODROMA CASTRO*), AN  
ENDANGERED HAWAIIAN SEABIRD

Carmen C. Antaky (antaky@hawaii.edu)<sup>1\*</sup>, Emily E. Conklin (conkline@hawaii.edu)<sup>2</sup>, Robert Toonen (toonen@hawaii.edu)<sup>3</sup>, Ingrid Knapp (iknapp@hawaii.edu)<sup>3</sup>, and Melissa R. Price (pricemel@hawaii.edu)<sup>1</sup>

<sup>1</sup>Department of Natural Resources and Environmental Management, University of Hawai'i at Mānoa, 1910 East-West Road, Honolulu, HI USA 96822

<sup>2</sup> Hawai'i Institute of Marine Biology, University of Hawai'i at Mānoa, 46-007 Lilipuna Rd., Kāne'ohe, HI USA 96744

The Hawaiian Band-rumped Storm Petrel ('Akē'akē; *Oceanodroma castro*), listed in 2016 as federally Endangered, nests in remote locations that are difficult to access and spends most of its life at sea. As such, very little is known about the movement among islands and the potential for establishing new breeding colonies in managed areas with predator controls. As a first step in assessing connectivity, in this study we evaluated patterns in genetic diversity among populations on the Main Hawaiian Islands. We performed next-generation sequencing (NGS) on DNA from blood, feather, or tissue samples collected from breeding colonies or downed individuals found on Kaua'i, O'ahu, Maui, and Hawai'i islands. Results suggest minimal differences between the Kaua'i and Hawai'i island populations. Genetic analyses revealed strong differentiation between the Maui population and those on Kaua'i and Hawai'i islands. Findings from this study may be used to inform seabird conservation efforts in Hawai'i. The maintenance of genetic diversity in future generations is an important consideration for conservation management of the Endangered *O. castro*.

GENETIC ASSIGNMENT OF NORTHERN FULMAR  
BYCATCH REVEALS CONTRIBUTIONS FROM MAJOR  
BREEDING COLONIES

Also alphabetized by Beck

Diana Baetscher (diana.baetscher@noaa.gov)<sup>1,2</sup>, Jessie Beck (jessie@oikonos.org)<sup>1\*</sup>, Michelle Hester (michelle@oikonos.org)<sup>3</sup>, Shannon Fitzgerald (shannon.fitzgerald@noaa.gov)<sup>4</sup>, Hannah Nevins (hnevins@abcbirds.org)<sup>3,5</sup>, and John Carlos Garza (carlos.garza@noaa.gov)<sup>1,2</sup>

<sup>1</sup>Department of Ocean Sciences, University of California, Santa Cruz, CA 95060

<sup>2</sup>NOAA Southwest Fisheries Science Center, Santa Cruz, CA 95060

<sup>3</sup>Oikonos Ecosystem Knowledge, Santa Cruz, CA 95062

<sup>4</sup>NOAA Alaska Fisheries Science Center, Seattle, WA 98115

<sup>5</sup>Present address: American Bird Conservancy, Santa Cruz, CA 95062

Pacific Northern Fulmars (*Fulmarus glacialis rodgersii*) overlap with U.S. North Pacific groundfish fisheries while foraging, resulting in incidental take of thousands of fulmars annually. The majority of these birds breed at four major colonies in the Bering Sea (Pribilofs, St. Matthew, Hall Is.), western Aleutians (Chagulak Is.) and Gulf of Alaska (Semidi Is.). Previously, it was demonstrated that, despite low levels of genetic differentiation, a set of 141 genetic markers can be used to link individual fulmars back to their natal colonies. We used these markers to evaluate the colony of origin for 1,536 fulmars caught as bycatch between 2006 and 2016. After quality filtering, 1,501 bycatch samples remained in the dataset and 47% of birds were assigned to one of the four colonies at a 90% likelihood (high confidence) threshold. Of these birds, 35% originated from the Semidi Is., 20% from the Pribilofs, 25% from St. Matthew and Hall Islands, and 20% from Chagulak Is. These results suggest that among the samples tested, bycatch is not equally distributed among breeding colonies and is not proportional to colony size. In particular, fulmars from the Pribilof Is. make up about a fifth of the bycatch specimens sampled, but comprise less than 10% of the overall breeding population of the species. Spatial and temporal collection information paired with genetic stock identification can help elucidate potential impacts of bycatch to individual colonies and the overall population of Pacific Northern Fulmars.

RESTORING OFFSHORE ISLANDS: LESSONS  
LEARNED FROM LEHUA, HAWAII.

Patricia Baiao (patty.baiao@islandconservation.org)<sup>1\*</sup>, Mele Khalsa<sup>1</sup> (mele.khalsa@islandconservation.org), Josh Atwood (Joshua.p.atwood@hawaii.gov)<sup>2</sup>, Sheri Mann (Sheri.S.Mann@hawaii.gov)<sup>2</sup>, Patrick Chee (patrick.c.chee@hawaii.gov)<sup>2</sup>, Shane Siers (Shane.R.Siers@aphis.usda.gov)<sup>3</sup>, Michael Fry (michael\_fry@fws.gov)<sup>4</sup>, Gregory Howald (Gregg.howald@islandconservation.org)<sup>1</sup>

<sup>1</sup>Island Conservation: 2100 Delaware Ave., Santa Cruz, CA. 95060

<sup>2</sup> Department of Land & Natural Resources, Division of Forestry & Wildlife, 3060 Eiwa St # 306, Lihue, HI 96766 or Kalanimoku Building 1151 Punchbowl St. Room 325 Honolulu, HI 9681

<sup>3</sup>USDA APHIS Wildlife Services National Wildlife Research Center, Hawaii Field Station, Hilo, HI

<sup>4</sup>USFWS

Islands are small, but they represent a significant proportion of biological diversity. They are the site of recently recorded species extinctions (Tershy et al. 2015) and invasive species play a prominent role being linked to 86% of all recorded island extinctions. The Hawaiian Islands are home several threatened species, many of which are threatened by Invasive Alien Species (IAS). Therefore, restoring offshore island ecosystems represent an unprecedented opportunity, and conservation interventions, such as the eradication of invasive species, have been demonstrated to result in benefits to native species in the terrestrial and marine habitats, as well as to local communities. However, eradication of IAS on islands are complex technical, social, and political exercises. A multi partner initiative to remove rats from Lehua Island is a representative example of the complexities that are encountered, with a thorough regulatory process at both federal and state level including compliance with the National Environmental Protection Act (NEPA) and Hawaii Environmental Policy Act (HEPA), as well as formal consultations on risk assessment to endangered species. Finally, an extensive community engagement strategy, that included a public-private steering committee with representatives from potentially affected communities, public meetings, radio shows, and printed media with the goal of providing transparency and the best available information on the potential benefits of the operation as well as the potential risks to native species and humans which revealed underlying conflict that created uncertainty.

#### TIME AFTER TIME: EARLY NEST INITIATION IS ASSOCIATED WITH HIGH REPRODUCTIVE SUCCESS AND PROBABILITY OF RE-NESTING BY CASPIAN TERNS IN THE COLUMBIA RIVER ESTUARY

Olivia A. Bailey (Olivia.Bailey@oregonstate.edu)<sup>1,\*</sup>, Daniel D. Roby (daniel.robby@oregonstate.edu)<sup>1</sup>, Donald E. Lyons (don.lyons@oregonstate.edu)<sup>1</sup>, and Yasuko Suzuki (yasuko.suzuki@oregonstate.edu)<sup>1</sup>

<sup>1</sup>Oregon Cooperative Fish & Wildlife Research Unit, Department of Fisheries and Wildlife, 104 Nash Hall, Oregon State University, Corvallis, OR 97331-3803 USA

A number of factors may explain differences in reproductive success among individual colonial nesting seabirds, including age, experience, nest site, and nest initiation date. We investigated the relative importance of these factors for explaining reproductive success of Caspian Terns (*Hydroprogne caspia*) at East Sand Island in the Columbia River estuary. During 2015 and 2016, we monitored the nesting attempts of a sample of individually marked terns and used a precise surveying instrument to measure the location of each nesting attempt relative to the colony edge and density of neighbor nests. Date of nest initiation explained greater variation in individual reproductive success over the two breeding seasons than other variables investigated. Reproductive success was strongly negatively associated with nest initiation date and was strongly positively associated with the density of nearby tern nests, although nest density was ranked below nest initiation date in relative importance. Nest location relative to the colony edge, age, and breeding experience each explained some, but less variation in reproductive success. Individuals that initiated nests earlier were more likely to re-nest if their initial nesting attempt failed; some individuals re-nested up to three times after failure of their first nesting attempt. Birds that re-nested for a second time were more successful than terns initiating their first attempt at similar times later in the season, suggesting that early nesters are more fit compared to those that initiated first nests later in the season. Overall, the timing of initiation of first nesting attempts in a season explained most of the variation in individual reproductive success.

#### NOAA'S NATIONAL SEABIRD PROGRAM: ADVANCING CONSERVATION, SUSTAINABLE FISHERIES, AND ECOSYSTEM-BASED MANAGEMENT THROUGH A FIVE-YEAR STRATEGIC PLAN

Lisa T. Ballance (Lisa.Ballance@noaa.gov)<sup>1,2,\*</sup>, Annette E. Henry (Annette.Henry@noaa.gov)<sup>1</sup>, Trevor Joyce (Trevor.Joyce@noaa.gov)<sup>1</sup>, Thomas P. Good (tom.good@noaa.gov)<sup>1</sup>, Robert M. Suryan (rob.suryan@noaa.gov)<sup>1</sup>, Jeannette E. Zamon (Jen.Zamon@noaa.gov)<sup>1</sup>, Shannon Fitzgerald

([Shannon.Fitzgerald@noaa.gov](mailto:Shannon.Fitzgerald@noaa.gov))<sup>6</sup>, and Jason E. Jannot ([jason.jannot@noaa.gov](mailto:jason.jannot@noaa.gov))<sup>3</sup>

<sup>1</sup>Southwest Fisheries Science Center, NOAA Fisheries, 8901 La Jolla Shores Drive, La Jolla, CA, USA 92037

<sup>2</sup>Scripps Institution of Oceanography, 8622 Kennel Way, La Jolla, CA, USA 92037

<sup>3</sup>Northwest Fisheries Science Center, NOAA Fisheries, 2725 Montlake Blvd. East, Seattle, WA, USA 98112

<sup>4</sup>Alaska Fisheries Science Center, NOAA Fisheries, 17109 Pt. Lena Loop Rd., Juneau, AK, USA 99801

<sup>5</sup>Northwest Fisheries Science Center, NOAA Fisheries, Pt. Adams Research Station, PO Box 155, Hammond, OR, USA 97121

<sup>6</sup>Alaska Fisheries Science Center, NOAA Fisheries, 7600 Sand Point Way NE, Seattle, WA 98115

NOAA Fisheries' National Seabird Program (NSP) was created in response to Executive Order 13186 (Responsibilities of Federal Agencies to Protect Migratory Birds) and the U.S. National Plan of Action for Reducing the Incidental Catch of Seabirds in Longline Fisheries. The NSP is a crosscutting group of managers and scientists who work domestically and internationally to protect and conserve seabirds as guided by statutes and emerging agency priorities. In May 2018, the NSP convened a two-day meeting to share ongoing research and goals, revisit and refine the NSP mission and vision, and draft a strategic plan. NSP representatives from every NOAA Fisheries science center, regional and headquarters offices, and invited participants from NOAA's National Ocean Service, the U.S. Fish and Wildlife Service, Bureau of Ocean Energy Management, and regional Fishery Management Councils attended. Five strategic initiatives were developed: (1) monitor and estimate seabird bycatch; (2) mitigate seabird bycatch; (3) strengthen key partnerships; (4) promote seabirds in advancing ecosystem-based fisheries management; and (5) elevate awareness of and support for NSP. These initiatives will form the framework for a five-year strategic plan that will promote awareness and value of seabirds, foster collaboration, and coordinate and direct resources to accomplish the goals and objectives established in the strategic plan.

#### PREDATION BY SEABIRDS ON SALMONIDS IN THE HUMBOLDT BAY REGION REVEALED BY COLONY RECOVERIES OF PIT TAGS

Daniel Barton ([daniel.barton@humboldt.edu](mailto:daniel.barton@humboldt.edu))\*, Rebecca Garwood ([rebecca.garwood@wildlife.ca.gov](mailto:rebecca.garwood@wildlife.ca.gov))<sup>2</sup>, James Ray ([james.ray@wildlife.ca.gov](mailto:james.ray@wildlife.ca.gov))<sup>2</sup>, Justin

Garwood ([justin.garwood@wildlife.ca.gov](mailto:justin.garwood@wildlife.ca.gov))<sup>2</sup>, Darren Ward ([darren.ward@humboldt.edu](mailto:darren.ward@humboldt.edu))<sup>1</sup>, and Colin Anderson ([colin.anderson@wildlife.ca.gov](mailto:colin.anderson@wildlife.ca.gov))<sup>2</sup>

<sup>1</sup>Humboldt State University, 1 Harpst Street, Arcata, CA 95521

<sup>2</sup>California Department of Fish and Wildlife, 619 2<sup>nd</sup> Street, Eureka, CA 95501

Predation by seabirds on fish is a key ecological process implicated in structuring marine and freshwater communities, and population growth of fish and bird species alike. Seabird predation on juvenile salmonids is difficult to observe directly, yet salmonid populations marked with passive integrated transponder (PIT) tags allow indirect observations of seabird predation when seabirds deposit these tags into nesting colonies after consuming them. In 2017-18, we searched five Double-crested Cormorant (*Phalacrocorax auritus*) and Caspian Tern (*Hydroprogne caspia*) colonies in the vicinities of Humboldt and Trinidad Bays, Humboldt County, California, and located 2521 PIT tags. We conducted repeat systematic surveys and excavated pits at one site (Sand Island, which had the majority of tag recoveries) to estimate detection probability. We determined the provenance of 2439 of these tags via collaboration with public agencies, tribal entities, and private groups in California, Oregon, Washington. Most identified tags were used to mark coho salmon (*Oncorhynchus kisutch*; 93.3%) and other salmonids (6.5%), and most (84.0%) were used to mark fish in the Humboldt Bay watershed. Some identified tags were last seen in fish in the Okanogan River in Washington, or Santa Cruz County, California. It is unclear if tags from distant watersheds were deposited by migrating local breeders or transient birds from other sites. Identified tags originated in 2004-2018, and mean salmonid length at time of marking was 99 mm (range 50-243 mm). We report tag population estimates corrected for recapture probability and provide what is likely a novel method for estimating abundance of pit tags at seabird colonies based on spatial capture-recapture.

#### GENETIC ASSIGNMENT OF NORTHERN FULMAR BYCATCH REVEALS CONTRIBUTIONS FROM MAJOR BREEDING COLONIES

Alphabetized by Baetscher and also by Beck

Diana Baetscher ([diana.baetscher@noaa.gov](mailto:diana.baetscher@noaa.gov))<sup>1,2</sup>, Jessie Beck ([jessie@oikonos.org](mailto:jessie@oikonos.org))\*, Michelle Hester ([michelle@oikonos.org](mailto:michelle@oikonos.org))<sup>3</sup>, Shannon Fitzgerald

(shannon.Fitzgerald@noaa.gov)<sup>4</sup>, Hannah Nevins (hnevins@abcbirds.org)<sup>35</sup>, and John Carlos Garza (carlos.garza@noaa.gov)<sup>1,2</sup>

<sup>1</sup>Department of Ocean Sciences, University of California, Santa Cruz, CA 95060

<sup>2</sup>NOAA Southwest Fisheries Science Center, Santa Cruz, CA 95060

<sup>3</sup>Oikonos Ecosystem Knowledge, Santa Cruz, CA 95062

<sup>4</sup>NOAA Alaska Fisheries Science Center, Seattle, WA 98115

<sup>5</sup>Present address: American Bird Conservancy, Santa Cruz, CA 95062

Pacific Northern Fulmars (*Fulmarus glacialis rogersii*) overlap with U.S. North Pacific groundfish fisheries while foraging, resulting in incidental take of thousands of fulmars annually. The majority of these birds breed at four major colonies in the Bering Sea (Pribilofs, St. Matthew, Hall Is.), western Aleutians (Chagulak Is.) and Gulf of Alaska (Semidi Is.). Previously, it was demonstrated that, despite low levels of genetic differentiation, a set of 141 genetic markers can be used to link individual fulmars back to their natal colonies. We used these markers to evaluate the colony of origin for 1,536 fulmars caught as bycatch between 2006 and 2016. After quality filtering, 1,501 bycatch samples remained in the dataset and 47% of birds were assigned to one of the four colonies at a 90% likelihood (high confidence) threshold. Of these birds, 35% originated from the Semidi Is., 20% from the Pribilofs, 25% from St. Matthew and Hall Islands, and 20% from Chagulak Is. These results suggest that among the samples tested, bycatch is not equally distributed among breeding colonies and is not proportional to colony size. In particular, fulmars from the Pribilof Is. make up about a fifth of the bycatch specimens sampled, but comprise less than 10% of the overall breeding population of the species. Spatial and temporal collection information paired with genetic stock identification can help elucidate potential impacts of bycatch to individual colonies and the overall population of Pacific Northern Fulmars.

#### COOPERATIVE MONITORING AND OUTREACH EFFORTS LEAD TO DECLINING HUMAN DISTURBANCE TO SEABIRD NESTING COLONIES

Cassie M. Bednar (cassie.bednar@humboldt.edu)<sup>\*</sup>, Gerard J. McChesney (gerry\_mcchesney@fws.gov)<sup>3</sup>, Richard T. Golightly (richard.golightly@humboldt.edu)<sup>3</sup>, Wendy

Kordesch (wendy.kordesch@noaa.gov)<sup>3</sup>, Paul Hobi (paul.hobi@noaa.gov)<sup>3</sup>, Karen Reyna (karen.reyna@noaa.gov)<sup>3</sup>

<sup>1</sup>Humboldt State University, Dept. of Wildlife, Arcata, California 95521 USA.

<sup>2</sup>U.S. Fish and Wildlife Service, San Francisco Bay National Wildlife Refuge Complex, Fremont, California 94555 USA.

<sup>3</sup>Seabird Protection Network, Greater Farallones National Marine Sanctuary, San Francisco, California 94129 USA

In central California, colonies of Common Murres (*Uria aalge*) and Brandt's Cormorants (*Phalacrocorax penicillatus*) are impacted by human disturbance from aircraft and watercraft. The Common Murre Restoration Project has conducted monitoring since 2005 at three key colonies: Point Reyes Headlands (PRH), Devil's Slide Rock & Mainland (DSR) and the Castle-Hurricane Colony Complex. All potential sources of human disturbance within 460 m horizontal distance and 305 m vertical distance from colonies were recorded as detection events. Any events that caused agitation (or, alarm), displacement, or flushing of seabirds were recorded as disturbance events. In addition, types and affiliations of detection and disturbance sources were recorded whenever possible. Using these data, the Seabird Protection Network (SPN; Greater Farallones National Marine Sanctuary) has conducted outreach to relevant user groups, specifically pilots and boaters, to increase awareness of seabird colonies, impacts of disturbance to seabirds in the region. Results of monitoring since 2005 show significant declining trends in annual detection rates (detections/hour) for all aircraft at PRH and DSR and for fixed-wing planes at all three colonies. Results for aircraft disturbance appear to show a declining trend, although not significant. Significant declining trends were found for annual watercraft detection rates at PRH and watercraft disturbance rates at PRH and DSR, including within a state Special Closure (no entry zone) established at DSR in 2010. These results indicate that the cooperative efforts of monitoring and outreach may be making positive strides toward reducing human disturbance at central California colonies.

#### MODELLING CANDIDATE MARINE CRITICAL HABITAT FOR MARBLED MURRELET (*BRACHYRAMPHUS MARMORATUS*) IN THE NORTHERN SALISH SEA.

Bertram, D.F. ([Douglas.bertram@dfo-mpo.gc.ca](mailto:Douglas.bertram@dfo-mpo.gc.ca))\*, O'Hara, P.D. ([paddioh@gmail.com](mailto:paddioh@gmail.com)), Robinson, C.L.K.R. ([Cliff.Robinson@dfo-mpo.gc.ca](mailto:Cliff.Robinson@dfo-mpo.gc.ca)), McCartney, L. ([mccartney.leon@gmail.com](mailto:mccartney.leon@gmail.com)), Morgan, K.H. ([Ken.Morgan@dfo-mpo.gc.ca](mailto:Ken.Morgan@dfo-mpo.gc.ca)), Faust, D. ([deborah\\_faust@hotmail.com](mailto:deborah_faust@hotmail.com)), and Woo, K. ([kerry.woo@canada.ca](mailto:kerry.woo@canada.ca)).

<sup>1</sup>ECCC, Institute of Ocean Sciences, Sidney, BC, V8L 4B2

<sup>2</sup>DFO, Pacific Biological Station, Nanaimo, BC, V9T 6N7

<sup>3</sup>ECCC, Pacific Wildlife Research Centre, Delta, BC, V4K 3N2

Canada's Marbled Murrelet Recovery Strategy uses a robust coast-wide model of suitable terrestrial nesting habitat and now requires information on marine Critical Habitat for British Columbia. Here we model candidate marine Critical Habitat in the northern Salish Sea to test methods which, if robust, could be used on a broader, coast-wide scale. We compare the results of MaxEnt and Random Forest models which each used 10 variables: bird distribution and abundance (KDEs from at-sea surveys adjusted for survey effort), bathymetry, bycatch of sand lance from juvenile salmon surveys, distance of each cell centroid (1km<sup>2</sup> resolution) to the closest suitable nesting habitat, distance of each cell centroid to closest shore, distance of each cell centroid to closest estuary, percent seabed slope, bottom current speed, and Pacific Sand Lance burying habitat. The sand lance burying layer was derived from a MaxEnt model driven mainly by a sand-shell layer bottom patch model, and including distance to terrestrial sand bluff, distance to sand and gravel beaches, depth, bottom tidal current, distance to estuary, shoreline exposure, and seabed slope. We discuss the model results in the Salish Sea and the utility of the techniques for application to other coastal regions.

## SEASONAL FOOD DEPLETION IN SHOREBIRD HABITATS

Joachim Bertrands ([joachimbertrands@gmail.com](mailto:joachimbertrands@gmail.com)),<sup>1,2,\*</sup>

<sup>1</sup>Wageningen University & Research Center, 6708 PB Wageningen, The Netherlands

<sup>2</sup>Simon Fraser University, 8888 University Dr, Burnaby, BC V5A 1S6, Canada

Foraging flight speed theory suggests that birds adapt their flight speed to habitat quality. Earlier research

suggests that flight speed (easy to measure) could be used as a parameter of estimating net intake rate (hard to measure). The prey consumed by Pacific Dunlins (*Calidris alpina pacifica*) presumably reproduce little or not at all during winter in the Fraser River Estuary, BC. Consequently, the prediction was that foraging intake rate declines over the course of the winter due to food depletion.

A radar unit was used, custom built for measuring flight speed of dunlins over the course of a full nonbreeding season. This enabled accurate measurements made throughout an entire tidal cycle. With help of a simple foraging model, translating easily-measured foraging flight speeds into estimates of difficult-to-measure energy consumption rates, it was possible to assess whether the feeding of dunlins along habitats measured declined over the course of a winter.

Preliminary results indeed show a significant decline in flight speed as well as power expenditure, although the fit is low for now. This and earlier research support the method we are developing which can potentially be used in many contexts, such as environmental impact assessment and development of new conservation strategies.

## SOME HARD-WORKING CASPIAN TERNS TAKE A SABBATICAL

Kirsten S. Bixler ([kirsten.bixler@oregonstate.edu](mailto:kirsten.bixler@oregonstate.edu))\*, Yasuko Suzuki ([yasuko.suzuki@oregonstate.edu](mailto:yasuko.suzuki@oregonstate.edu)), Timothy J. Lawes ([timothy.lawes@oregonstate.edu](mailto:timothy.lawes@oregonstate.edu)), Donald E. Lyons ([don.lyons@oregonstate.edu](mailto:don.lyons@oregonstate.edu)), and Daniel D. Roby ([daniel.robby@oregonstate.edu](mailto:daniel.robby@oregonstate.edu)).

<sup>1</sup>Oregon Cooperative Fish and Wildlife Research Unit, Department of Fisheries and Wildlife, 104 Nash Hall, Oregon State University, Corvallis, OR 97331 USA

<sup>2</sup>National Audubon Society Seabird Restoration Program and Department of Fisheries and Wildlife, Oregon State University, 104 Nash Hall, Corvallis, OR 97331-3803 USA

Skipped breeding can affect both parental survival and lifetime reproductive success in long-lived seabirds, but has not been well documented in most tern species. We placed field-readable leg-bands on nearly 7500 Caspian Terns (*Hydroprogne caspia*) in Oregon from 2001 to 2011 and used this banded cohort to examine the proportion of Caspian Terns that skipped breeding at the East Sand Island colony during a 3-year

period when colony size was fairly stable (~6000-7500 nesting pairs) and nesting density was >1 nest/m<sup>2</sup>. Although the detection probability of banded terns at East Sand Island was high, confirmation of nesting attempts by banded individuals was more difficult. We used a proxy measure to substitute for confirmed breeding activity; any banded individual resighted at East Sand Island on 5 different days within a 90-day breeding period was considered a “breeder.” Of 246 “breeders” documented in both 2012 and 2016 at East Sand Island, an average of 22 (8.9%, range=4.1% to 12.2%) took a sabbatical from breeding in each of the 3 intervening years. A total of 48 “breeders” (19.5%) took a sabbatical from breeding for at least 1 of the 3 years; 13% took a sabbatical for 1 year, 5.7% for 2 years, and 0.8% for all 3 years. All “breeders” were resighted at least once at East Sand Island in all years suggesting that the decision to take a sabbatical from breeding may be based on conditions at the colony, such as availability of nest sites or forage fish.

#### SEA BIRDS IN MAKAH CULTURE

Kylee Butler\* (kyleejo767@hotmail.com)

Makah Tribal Member

Birds were part of the marine food tradition but not much is known about the specifics of hunting techniques, which species and in what abundance or the use of various parts of the birds. Through discussions with Makah tribal elders who have participated in sea duck hunting on the Waatch, and examination of some of the artifacts currently located at the Makah Cultural and Research Center (MCRC) I will piece together what is known about this tradition and examine how marine birds fit into current culture in Neah Bay, WA. Preliminary interviews with elders provide indigenous insights into which tools were used and how they were used. Bows found at the Ozette excavation in the 70's have been identified as bird hunting bows. It is known that common mergansers (*Mergus merganser*) were hunted as recently as 30 years ago on the Waatch River. The Makah language for marine birds and their product will be explored.

#### POPULATION GENETIC STRUCTURE OF RED-FACED AND PELAGIC CORMORANTS IN THE ALEUTIAN AND PRIBILOF ISLANDS

Dustin Carl (djcarl@alaska.edu)<sup>1\*</sup> and Douglas Causey (dcausey@alaska.edu)<sup>1,2</sup>

<sup>1</sup>Dept Biological Sci, U Alaska Anchorage, 3211 Providence Drive, Anchorage, AK 99508

<sup>2</sup>Dept Fisheries, U Alaska Fairbanks College of Fisheries and Ocean Sciences, Fairbanks, AK 99775

Recent local declines in population numbers of Red-faced and Pelagic Cormorants (*Phalacrocorax urile* and *P. Pelagicus*) have prompted increasing attention on understanding the possible factors affecting the breeding success and ecological correlates of population distribution and abundance. Rapid and severe regional declines of Red-faced Cormorants, particularly in the Western Aleutian Islands and the Pribilof Islands, have prompted its designation as a Priority Species by USFWS Region 7. Although both Red-faced and Pelagic Cormorants have a widespread distribution and are sometimes locally abundant, little is known about the population dynamics of either species. In order to best manage these species it needs to be determined whether observed declines in abundance and breeding success require local, regional, or species -wide conservation efforts. To determine the appropriate level for management and conservation efforts for these species, it must first be determined whether these species have an ecological or genetic metapopulation structure.

Genetic differentiation of seabird populations between separate archipelagos or regions has been reported for several species, particularly for species where dispersal is limited. Winter studies suggest Red-faced Cormorants are resident year-round throughout their breeding range, and many birds remain near their breeding colony in winter. In addition, peripheral populations are more likely to be genetically distinct from populations nearer to the center of a species distribution due to the limited dispersal options for birds on the periphery. This is especially true for a species like Red-faced Cormorants with a geographic range that is latitudinally compressed. Given the perceived low rate of dispersal of Red-faced Cormorants it is very possible that genetic structure exists within the species, particularly for populations near the edge of the species distribution such as the Western Aleutian and Pribilof Islands.



The results of this study will be used to determine if significant genetic population structure exists for either Red-faced or Pelagic Cormorants. Further, if population structure does exist, the results of this study will help determine if separate populations of these species are distinct to the point that they need to be managed as discrete conservation units, in order to best preserve genetic diversity at the species level.

#### THE EFFECTS OF RAPID DESTABILIZATION OF COASTAL MARINE ECOSYSTEMS

Douglas Causey (dcausey@alaska.edu)<sup>\*,</sup> Ashley Stanek (aestanek@alaska.edu)<sup>1,</sup> Kate Sheehan (KateSheehan@saumag.edu)<sup>2,</sup> Kurt Burnham (kburnham@higharctic.org)<sup>3</sup>

<sup>1</sup>Dept Biological Sci, U Alaska Anchorage, 3211 Providence Drive, Anchorage, AK 99508

<sup>2</sup>Dept Biological Sci, Southern Arkansas Univ, Magnolia AR USA

<sup>3</sup>High Arctic Institute, 603 10<sup>th</sup> Avenue, Orion, IL 61273

Understanding the complex dynamics of environmental change in northern latitudes is particularly critical for Arctic coastal communities, which are at the interface between land and sea. Coastal marine foodwebs are more complex and interconnected—even in the High Arctic—by comparison to those found in adjacent terrestrial and offshore marine ecosystems. Quantitative assessment of marine foodweb structure and dynamics is challenging given the difficulty in direct sampling of organisms in the water column, particularly so in Arctic regions. We utilize instead indirect methods that allow reconstruction of foodweb structure and entropic stability within a broad range of spatial and temporal scales using birds as proxy indicators of change. Avian communities of marine and terrestrial Arctic environments represent a broad spectrum of trophic levels, from herbivores, planktivores, insectivores, nearshore and offshore fish, even other bird species.

We have been reconstructing the foodweb ecology using stable isotopes (d<sup>13</sup>C, d<sup>15</sup>N, d<sup>34</sup>S), parasites, and diet reconstruction of contemporaneous coastal bird communities in High Arctic (Northwest Greenland) and Low Arctic (Aleutian and Bering Sea islands, AK). Initial findings indicate that in the past decade Arctic coastal foodwebs are increasingly less predictable with higher structural variance, less complex, simpler

trophic structure, and possibly with different species composition. Analysis of archival specimens collected over 150 years show that these patterns appear to be similar throughout the Arctic, but with the effect gradient increasing with latitude and time. We discuss the potential fine-scale implications of change on High Arctic coastal ecosystems and the effect on seasonal breeding populations of marine and terrestrial animals.

#### SEABIRDS SAMPLE PLASTIC POLLUTION: BONIN PETRELS (*PTERODROMA HYPOLEUCA*) AS BIOINDICATORS OF PLASTIC IN THE NORTH PACIFIC

Lauren Chamberlain<sup>\*,</sup> (lfraser@my.hpu.edu) and David Hyrenbach<sup>1</sup>

<sup>1</sup>Hawaii Pacific University, 1164 Bishop St, Honolulu, HI 96813

Bonin Petrels (*Pterodroma hypoleuca*) have been characterized by high incidence of marine plastic ingestion with 75 – 100% of sampled individuals containing debris. We contend that Bonin Petrels are ideal bioindicators of pelagic plastic pollution for the Northwestern Hawaiian Islands due to their breeding phenology, stomach anatomy, and foraging ecology. Our goal was to create baseline data for this species, develop necropsy protocol for the future and gain insight to the types of plastic consumed. Necropsies were performed on 84 Bonin Petrel specimen collected from Midway Atoll to characterize body condition and plastic ingestion. Samples remained separate by age class and stomach chambers. Plastic samples were categorized by type, size, and polymer composition. 95% of hatch-year birds had ingested plastic (n=42); 83% had plastic in the gizzard and 60% had plastic in the proventriculus. Among this sample, 79% of the birds ingested fragments with an average mass of 0.0099 ± 0.0157 g. 88% of the birds ingested line with an average mass of 0.0042 ± 0.0078 g. 93% of after-hatch-year birds had ingested plastic (n=42), 93% had plastic in the gizzard and 19% had plastic in the proventriculus. Among this sample, 69% of the birds ingested fragments with an average mass of 0.0086 ± 0.0146 g. 83% of these birds ingested line with an average mass of 0.0025 ± 0.0019 g. Fragments and line make up the majority of ingested plastic types, giving insight into the types of plastic floating in their foraging region. Overall, there was more plastic in the gizzard than the proventriculus as well as more plastic in hatch-year birds compared to after-hatch-year

birds, expressing the need to keep these factors separate to avoid sampling bias.

THE PHYLOGENETIC POSITION AND GENETIC EVIDENCE OF HYBRIDIZATION OF THE CRITICALLY ENDANGERED CHINESE CRESTED TERN  
Alphabetized by Chen

Jia Yang (yjiangling@163.com)<sup>1</sup>, Guoling Chen(chengl25@mail.sysu.edu.cn)<sup>2</sup>, Leyang Yuan(yuanly@zmnh.com)<sup>1</sup>, Qin Huang(rshuangqin@gmail.com)<sup>1,2</sup>, Zhongyong Fan(fanzhy@zmnh.com)<sup>1</sup>, Yiwei Lu(luyw@zmnh.com)<sup>1</sup>, Siyu Wang(812355207@qq.com)<sup>1</sup>, Yang Liu(liuy353@mail.sysu.edu.cn)<sup>1,\*</sup>, Shuihua Chen(chensh@zmnh.com)<sup>1,\*</sup>

<sup>1</sup>Zhejiang Museum of Natural History, Hangzhou, 310014, China

<sup>2</sup>State Key Laboratory of Biocontrol, School of Life Sciences, Sun Yat-sen University, Guangzhou, 510275, China

Determining the phylogenetic relationship among species is central to understanding their evolution and biodiversity. Paradoxically, the phylogenetic position of threatened species, such as the critically endangered Chinese Crested Tern (*Thalasseus bernsteini*), is often unresolved because of their rarity. Here we examine mitochondrial loci data and demonstrate that the Chinese Crested Tern and Great Crested Tern (*T. bergii*) are sister species. These two species appear to have diverged approximately 0.75 mya and are members of the genus *Thalasseus*. We argue that the diversity in the genus *Thalasseus* arose due to allopatric speciation in glacial age. Further our multi-locus analyses suggest the possibility of hybridization occurred between the Chinese Crested Terns and Great Crested Terns, and might be the gravest current threat to the endangered the Chinese Crested Tern. Our findings also call the need of monitoring hybridization in the conservation management of the Chinese Crested Terns.

TOWARD A COMPLETE PHYLOGENY OF THE PROCELLARIIFORMES

R. Terry Chesser<sup>1</sup> (chessert@si.edu), Helen F. James<sup>2</sup> (jamesh@si.edu), Vincent Bretagnolle<sup>3</sup> (Vincent.Bretagnolle@cebc.cnrs.fr), Andrea Estandía<sup>4</sup> (andrea.estandia@durham.ac.uk), Max A.

Levy<sup>4</sup> (max.levy@durham.ac.uk), Andreanna J. Welch<sup>4</sup> (a.j.welch@durham.ac.uk)

<sup>1</sup>Patuxent Wildlife Research Center, U.S. Geological Survey

<sup>2</sup>National Museum of Natural History, Smithsonian Institution

<sup>3</sup>Equipe AGRIPPO, CEBC-CNR

<sup>4</sup>Dept. of Biosciences, Durham University

The Procellariiformes are by far the largest group of oceanic birds, but no complete phylogeny of the order is available. Most previous molecular studies of the group have been based on small amounts of data, generally sequences of the mitochondrial gene cytochrome-b, and have suffered from a lack of resolution owing to the small amount of sequence data, especially at deeper phylogenetic levels. In contrast, recent large-scale genomic studies of avian phylogenetics have necessarily included only a few representatives of the Procellariiformes.

We are using genomic sequence capture of UCEs to study evolutionary relationships of all extant and recently extinct Procellariiformes, sampling 2-4 individuals of all ca. 130 extant and recently extinct species. Our overarching goal is to develop a phylogenomic framework for studying the evolutionary and ecological history of oceanic birds. A well-resolved species- and subspecies-level tree will enable us to perform comparative studies of diversification and trait evolution in the Procellariiformes, which vary tremendously in body size, wing morphology, ecological niche, foraging behavior, and extinction risk. Preliminary data from selected species produced a well-resolved and well-supported backbone phylogeny, enabling us to address relationships among families and the relationships of problematical taxa such as the fulmarine petrels and the Kerguelen Petrel *Aphrodroma brevirostris*.

A NEW PROTOCOL FOR MONITORING TUFTED PUFFINS IN THE ALASKA MARITIME NATIONAL WILDLIFE REFUGE

Aaron Christ (aaron\_christ@fws.gov)\* and Brie Drummond (brie\_drummond@fws.gov)

Alaska Maritime NWR, 95 Sterling Hwy Suite 1, Homer, AK 99603

Tufted puffins have attracted substantial recent concern due to population declines and colony

abandonment in parts of their range, and the species is currently being considered for endangered species protection. However, population status and trend information from colonies in Alaska, where most of the world's tufted puffin population breed, are limited and difficult to collect because of the large number of colonies, vast expanse of the area, and remoteness of most sites. The Alaska Maritime National Wildlife Refuge, which supports the majority of Alaska's tufted puffin colonies, is developing a new monitoring protocol to better assess changes in tufted puffin populations in Alaska. We present a pilot study of this protocol from six islands in 2018, three with ongoing annual seabird monitoring camps and three at less frequently monitored sites. We also discuss further refinements for improvements based on this year's results.

#### CONTAMINANTS AS ECOLOGICAL TRACERS: DOES MERCURY LOAD REFLECT FORAGING HABITS OF A GENERALIST SEABIRD?

Corey Clatterbuck (cclatterbuck@ucdavis.edu)<sup>1,2\*</sup>, Rebecca Lewison (rlewison@sdsu.edu)<sup>1</sup>, Rachael Orben (raorben@gmail.com)<sup>3</sup>, Rob Suryan (rob.suryan@oregonstate.edu)<sup>3</sup>, Leigh Torres (Leigh.Torres@oregonstate.edu)<sup>3</sup>, Josh Ackerman (jackerman@usgs.gov)<sup>4</sup>, Hillary Young (hillary.young@lifesci.ucsb.edu)<sup>5</sup>, and Scott Shaffer (scott.shaffer@sjsu.edu)<sup>6</sup>

1. San Diego State University, Biology Department, San Diego CA USA
2. University of California-Davis, Graduate Group in Ecology, Davis CA USA
3. Oregon State University, Department of Fisheries and Wildlife, Hatfield Marine Science Center, Newport OR USA
4. U.S. Geological Survey, Western Ecological Research Center, Dixon Field Station, Dixon CA USA
5. University of California Santa Barbara, Department of Ecology, Evolution, and Marine Biology, Santa Barbara CA USA
6. San Jose State University, Department of Biological Sciences, San Jose CA USA

Mercury is a commonly monitored contaminant in seabirds because of its adverse impacts on avifaunal reproduction and survival, but is rarely used as an ecological tracer. Biogeochemical processes can alter mercury bioavailability at multiple spatial scales and habitats, resulting in complex signatures among free-

ranging animals. However, when combined with additional foraging data, mercury may be an ideal tracer to link contaminant load to exposure risk among colonies and associated foraging pathways or sites. Here, we pair blood mercury concentrations and GPS tracking data in breeding western gulls (*Larus occidentalis*, N=156) from five colonies in coastal California and Oregon, USA, to explore the extent to which blood mercury burdens reflect short-term gull foraging spatial patterns. We used a Hidden Markov Model to identify putative behaviors and foraging locations from GPS tracks. We then compare individual and colony movement metrics to measured blood mercury values both within and among colonies. Our results connect mercury concentrations with marine and terrestrial foraging in gulls and provide insight into the foraging differences and differences in mercury exposure among breeding western gulls across their range.

#### PREDATOR CONTROL ON A NAVY INSTALLATION: KEEPING THE ENEMY AT BAY

Marcus A. Collado\*, Caleb J. Morrison, and Gordon Willson-Naranjo

Research Corp of the University of Hawaii/US Navy Pacific Missile Range Facility, PO Box 128 PMRF Public Works Office Bldg. 395, Kekaha, HI 96752

The Pacific Missile Range Facility (PMRF) Natural Resources Predator Control Program is a Department of the Navy project, administered through the Pacific Cooperative Studies Unit (PCSU) of the University of Hawai'i. The Navy is committed to managing its lands responsibly and protecting the species that live upon it while furthering the various missions and goals. PMRF is a small US Navy base located on Kaua'i that serves as an instrument and missile testing range, with facilities in Koke'e State Park, Makaha Ridge, Barking Sands, and Ni'ihau Island. Many protected species visit, breed, or transit through these facilities, and the PMRF Predator Control team is tasked with protecting these species by reducing the numbers of introduced non-native predators and ungulates on Navy lands. Intensive trapping of feral cats and rodents has been the focus of the program, in addition to controlling loose dogs and Barn Owls. Since the inception of the PMRF Predator Control program in Nov 2016, 208 feral cats have been removed from PMRF using a combination of methods. 94 rats have been caught as by-catch in feral cat traps, and an array of 30 Goodnature A24 traps has been in operation since Aug 2017, with each trap capable of up

to 24 activations before servicing. We also respond immediately to any sightings of loose dogs, which have been responsible for massacres of seabirds such as Wedge-tailed Shearwaters and Laysan Albatrosses at PMRF in the past. Loose dogs are caught by hand via noose-pole or trapped in a large cage trap and either returned directly to their owner or sent to the Kaua'i Humane Society. We are committed to increasing our abilities to more effectively protect species present on base and are actively pursuing permissions to use high-powered airguns, firearms, and different trapping methods for Barn Owls, feral pigs, and feral goats.

#### USING LIFE HISTORY TO INFORM MARINE SPATIAL PLANNING FOR THE PROTECTION OF WIDE-RANGING PELAGIC SEABIRDS

Melinda Conners (melinda@green-st-wildlife.com)<sup>1</sup>, Sara Maxwell (smmax@uw.edu)<sup>1</sup>, Scott Shaffer (scott.shaffer@sjsu.edu)<sup>2</sup>, Rachael Orben (rachael.orben@oregonstate.edu)<sup>3</sup>, Alastair Baylis (al\_baylis@yahoo.com.au)<sup>4,5</sup>.

<sup>1</sup>University of Washington, 18115 Campus Way NE, Bothell, WA 98011 USA

<sup>2</sup>San Jose State University, San Jose CA 95192-0100

<sup>3</sup>Oregon State University, Hatfield Marine Science Center, Newport, OR 97365

<sup>4</sup>South Atlantic Environmental Research Institute, Stanley FIQQ 1ZZ, Falkland Islands

<sup>5</sup>Falklands Conservation, Stanley FIQQ 1ZZ, Falkland Islands

Large and persistent declines in seabird populations have led to conservation action, including the designation of marine protected areas (MPAs). MPAs are a critical tool for conserving marine systems; however, their effectiveness is debatable for protecting highly mobile species. Given that many seabird species cover vast areas, MPA design often focuses on species that aggregate in space and time and whose home ranges fall within political EEZs. Nonetheless, concerns over significant population declines and growing interests in high seas MPAs underscore the need to understand spatio-temporal dynamics of occurrence in wide-ranging species. We measured home ranges from 15 tracking datasets from 11 seabird species whose ranges vary from localized (10<sup>3</sup> km<sup>2</sup>) to vast (>10<sup>6</sup> km<sup>2</sup>), and we compared home range with sizes of existing MPAs. We then isolated three wide-ranging species: Laysan and black-footed albatross (*Phoebastria immutabilis*, *P. nigripes*) and

sooty shearwaters (*Ardenna grisea*) to demonstrate range dynamics across various life history stages and to identify when and where feasibility of protection is the greatest. We found that 88.7% of MPAs are large enough to protect localized species, but only 6.7, 3.9, and <1% are suitable for protecting intermediate, large, and vast-ranged species. However, life history had a strong influence on home range size across the annual cycle, and we highlight spatial patterns that increase feasibility for protection of highly mobile species in certain times of the year (e.g. molting, chick-rearing). Though protecting entire ranges of wide-ranging seabirds is an intractable challenge, we emphasize that systematic protection may be feasible when isolating discrete life history phases.

#### STATUS AND NEST SURVIVAL OF ALEUTIAN AND ARCTIC TERNS BREEDING IN THE KODIAK ARCHIPELAGO, 2016-2018

Alphabetized by Corcoran and also by Tengeres

Jill E. Tengeres<sup>1</sup> (jill.tengeres@oregonstate.edu), Robin M. Corcoran<sup>2</sup>, and Donald E. Lyons<sup>3</sup> (dlyons@audubon.org)

<sup>1</sup>Department of Fisheries and Wildlife, Oregon State University, 104 Nash Hall, Corvallis, OR.

<sup>2</sup>U.S. Fish and Wildlife Service, Kodiak National Wildlife Refuge, 1390 Buskin River Rd., Kodiak, AK.

<sup>3</sup>National Audubon Society Seabird Restoration Program and Department of Fisheries and Wildlife, Oregon State University, 104 Nash Hall, Corvallis, OR.

Aleutian terns (*Onychoprion aleuticus*) are colonial nesting seabirds that breed in coastal Alaska and the Russian Far East, often in association with Arctic terns (*Sterna paradisaea*). Tern colonies in the Kodiak Archipelago have been the focus of periodic monitoring and research since the 1970s, providing valuable information on the status and ecology of both species. Seabird colony records from the 1970s-2018 identify 53 sites in the Archipelago with a history of tern nesting. During the 2016-2018 breeding seasons we surveyed for terns at all 53 colony sites and searched for new colonies. Across the three breeding seasons, Arctic terns were active at 28 colonies, and Aleutian terns were observed at 12 colonies. We monitored nest survival through hatch by placing digital game cameras at 68 Aleutian tern nests at seven colonies, and 11 Arctic tern nests at five colonies. Only seven camera nests survived to hatch (six Aleutian tern and one Arctic tern nest), and to our knowledge

none of these nests successfully fledged chicks. Predation was the leading cause of nest failure, followed by nest abandonment, often associated with flooding of nests at the high tide. Red fox were the most common nest predator for both tern species, but the nest predator assemblage was diverse and included glaucous-winged gulls, mew gulls, black-billed magpies, northwestern crows, brown bears, and short-tailed weasels. Due to high predation rates, variable nest initiation dates and re-nesting propensity, and frequent colony abandonment it was challenging to confirm nesting or determine nest success despite camera deployment and multiple visits to most colonies each season.

#### SEASONAL PATTERNS AND METRICS OF MARBLED MURRELET (*BRACHYRAMPHUS MARMORATUS*) VOCAL ACTIVITY FROM AUTONOMOUS RECORDING UNITS

Jenna L. Cragg<sup>1</sup>\*, F. Louise Waterhouse<sup>2</sup>, Frank I. Doyle<sup>3</sup>, Monica H. Mather<sup>1</sup>, Bernard K. Schroeder<sup>4</sup>

<sup>1</sup>Ministry of Forests, Lands and Natural Resource Operations, 2080 Labieux Rd, Nanaimo BC V9T 6J9

<sup>2</sup>Ministry of Forests, Lands and Natural Resource Operations, 2100 Labieux Rd, Nanaimo BC V9T 6E9

<sup>3</sup>Wildlife Dynamics Consulting, P.O. Box 3596, Smithers, B.C. V0J 2N0

<sup>4</sup>Bernard K. Schroeder Consulting, 351 Howard Ave. Nanaimo BC V9R 3R8

The Marbled Murrelet (*Brachyramphus marmoratus*) is a Threatened species under the *Species At Risk Act* in Canada. In support of meeting regional habitat retention targets for the British Columbia Marbled Murrelet Implementation Plan (2018), we assessed the utility of autonomous recording units (ARUs) to sample murrelet vocal activity in potential nesting habitat from 2016-2018. We compared results of season-long ARU sampling to detections from audio-visual (AV) and radar surveys to describe murrelet vocal behaviours related to nesting across a range of forest patch sizes (n = 36, range 4.4 – 70 ha), in 5 landscapes ranging in levels of fragmentation. In 2016-2017, AV and radar surveys were conducted at 16 and 13 sites, respectively. Murrelet presence was detected by ARUs at all 11 AV, and 13 radar sites where murrelets were detected by these methods, and at 2 sites where AV detections were absent due to low sampling effort. Murrelets were detected by ARUs throughout deployment (May-August), an average of 40% of sampled days (range 0-82%). ARU sites with

>15 maximum detections per dawn survey (“abundant”) also had the strongest activity peaks in July, corresponding to timing of chick-rearing and fledging; and 5 of 6 sites classified by AV as “occupied” also had “abundant” ARU detections, suggesting that these metrics have some association to local breeding effort. Patterns of abundance observed by radar did not match ARU detections, with high-activity ARU sites (30, 79 maximum detections) having low radar detections (12-17). This suggests that the smaller sampling radius of ARUs (approximately 200 m) can provide a more reliable indication of local stand activity relative to radar surveys.

#### CALCULATING CARBON-AWARE CONFERENCE LOCATIONS FOR ANNUAL MEETINGS OF THE PACIFIC SEABIRD GROUP.

David Craig ([dpcraig@willamette.edu](mailto:dpcraig@willamette.edu)) and Angel Espinoza Robles ([aaespinoza@willamette.edu](mailto:aaespinoza@willamette.edu)), Willamette University, 900 State Street, Salem, OR USA 97301

Pacific Seabird Group annual meetings allow for the rapid sharing of new ideas and are a vital part of our scientific community, but these meetings also generate greenhouse emissions that contribute to climate changes that are harming seabirds. Scientists including conservation oriented biologists often generate much greater greenhouse admissions that the average non-scientist primarily because of travel to conduct research or to attend professional meetings. Using attendance data for the current annual meeting of the Pacific Seabird Group I estimate greenhouse gas emissions for all attendees using the shortest possible direct flight or drive to the meeting site in Hawaii. Estimates of the future greenhouse emissions that will be generated for upcoming meeting in Portland, Oregon (2020) and San Diego (2021) are also modeled. I do not suggest that meetings should be done away with, but as responsible members and participants, we should clearly do what we can to minimize the ecological costs of our meetings. I propose including ecological costs related to travel distances and greenhouse gas emissions as a significant factor in choosing future meeting locations.

#### GLOBAL META-POPULATION VIABILITY ANALYSIS DETERMINES RELATIVE EXTINCTION RISK AMONG THREATENED SEABIRDS

Donald Croll (dcroll@ucsc.edu)\*, Kelly (Newton) Zilliacus (kzilli@ucsc.edu), M. Tim Tinker (ttinker@nhydra.com), Diana Ruiz (dmadruga@ucsc.edu), and Bernie Tershy (tershy@ucsc.edu):

<sup>1</sup> University of California Santa Cruz, 115 McAllister Way, Santa Cruz, CA USA 95060

<sup>2</sup> Nhydra Ecological Consulting, 11 Parklea Drive, Head of St. Margarets Bay, Nova Scotia, Canada B3Z 2G6

To prevent additional seabird extinctions, conservation practitioners need to know where to take action and what actions are most effective. We combined a global database on the breeding location, population meta structure, and anthropogenic threats with a detailed demographic and population database to develop a spatially explicit meta-population viability analysis (mPVA) model for all IUCN threatened (Critically Endangered, Endangered, Vulnerable) seabirds. We completed an extinction risk analysis for all extinction probability models for 94 insular threatened seabird species to determine which species are at Extreme (>75% Risk Index) or High (50 – 75% Risk Index) risk of extinction across a 100 year time horizon. Our analysis identifies six types of conservation opportunities: 1) seabird species at extreme or high risk of extinction in the next century, 2) families of seabirds (Procellariids) that include the largest proportion of species with extreme or high risk of extinction, 3) the potential mitigation in extinction risk to be gained by conducting all feasible eradications of damaging invasive vertebrates on at least one breeding island of extreme/high risk seabirds, 4) the potential mitigation in extinction risk to be gained by potentially conducting translocations/reintroductions to establish new breeding colonies of extreme/high risk seabirds, and 5) fundamental new tools or competencies necessary to maximize the potential impact of seabird conservation.

#### INDIVIDUAL REPRODUCTIVE STRATEGIES OF HEERMANN'S GULL (*Larus heermanni*), NESTING IN RASA ISLAND, GULF OF CALIFORNIA, MEXICO

Gabriela De la Cruz-Pino (gabi\_pino.16@hotmail.com)\*, Enriqueta Velarde (enriqueta\_velarde@yahoo.com.mx), Mark Marín-Hernández (markmarin@uv.mx), Ernesto Ruelas-Inzunza (ruelas.uv@gmail.com):

<sup>1</sup>Universidad Veracruzana, Instituto de Ciencias Marinas y Pesquerías, 617 Hidalgo Street, Col. Río Jamapa, Boca del Río, Veracruz, MX 94290

<sup>2</sup>Universidad Veracruzana, Instituto de Biotecnología y Ecología Aplicada, 101 USBI Avenida de las Culturas Veracruzanas, Xalapa, Veracruz, MX 91090

Reproduction is one of the most important factors in the life history of organisms. In iteroparous and long-lived species, such as seabirds, the age of first reproduction, parental care, reproductive success, self-maintenance (survival), longevity, and diet play a crucial role in their life history. Isla Rasa, located in the Midriff Islands Region of the Gulf of California, is the nesting site for 95% of the world's Hermann's gull (*Larus heermanni*) population. This species has demonstrated high fidelity to the nesting site, as well as reproductive strategies such as avoiding reproduction until favorable food conditions exist, longevity, late sexual maturation and low reproductive rate. However, differences in the effect of cohort, and environmental anomalies on chick productivity, have not been individually characterized. The objective of this preliminary study is to assess the effect of the cohort on the total chicks produced by female, and chicks produced by females between normal and high sea surface temperature (SST) conditions. For this, we analyzed 61 females from seven cohorts, ringed at the fledging age, between 1984 and 1993, and recaptured in years subsequent to their sexual maturation until 2013. Preliminary results show that in normal years average chick production per female is 0.83, while in anomalous years average chick production per female is 0.065. Moreover, the most important factor that determines reproductive success is the anomaly of SST. This suggests that gulls prioritize self-maintenance, by reducing or cancelling breeding in anomalous years as a reproductive strategy, both, because of its specialized diet of forage fish, and limited nesting site.

#### DETERMINANTS OF POST-FLEDGING SURVIVAL IN TRANSLOCATED ALBATROSS CHICKS

Tomohiro Deguchi (deguchi@yamashina.or.jp)\*, Robert M Suryan (rob.suryan@noaa.gov), Fumio Sato (sato@yamashina.or.jp) and Kiyooki Ozaki (ozaki@yamashina.or.jp):

<sup>1</sup>Yamashina Institute for Ornithology, 115 Konoyama, Abiko, Chiba Japan 270-1145

<sup>1</sup>NOAA Fisheries, Alaska Fisheries Science Center, Auke Bay Laboratories, 17109 Point Lena Loop Rd., Juneau, AK USA 99801

Post-fledging survival rate of translocated chicks is an important factor determining seabird restoration success. We translocated 70 short-tailed albatross chicks from source colony, Torishima, to a historical breeding site, Mukojima, and hand-reared them during 2008-2012. Sixty-nine chicks fledged and 37 birds (54%) were observed at least once on Torishima or Mukojima by 2018. Of the fledglings that returned to Torishima, 99% were resighted by 6 years of age. We analyzed the effects of sex, translocation age, growth rate, fledging age, fledging size, transmitter attachment method, and sea wave height after fledging on the return probability of translocated birds. Our results indicate high sea wave height decreased the return probability of translocated birds (62% return probability with wave height less than 1.5m and 43% with more than 1.5m). The return probability was lower in birds with transmitters attached by harness (25%) than birds with transmitters attached by tape (57%) or without transmitters attached (58%). Reduced probability with transmitters attached by harness was also confirmed in naturally reared fledglings from Torishima during the same study period (harness: 25%, tape: 56%). Whereas transmitter attached by harness provided information on migration and multi-year at-sea distribution, transmitter attached by tape were sufficient in providing valuable short-term (< 6 months) survival information post fledging while we developed hand-rearing techniques - without compromising long-term survival as harness did. We recommend considering transmitter attachment method, if used, and sea conditions near translocation site in planning seabird translocation projects.

#### HABITAT PREFERENCES OF CASSIN'S AUKLETS REVEALED THROUGH GPS TRACKING

Alice Domalik (adomalik@sfu.ca)<sup>1\*</sup>, Mark Hipfner (mark.hipfner@canada.ca)<sup>2</sup>, Katharine Studholme (krstudholme@dal.ca)<sup>3</sup>, Glenn Crossin (glenn.crossin@dal.ca)<sup>3</sup>, and David Green (djgreen@sfu.ca)<sup>1</sup>

<sup>1</sup>Centre for Wildlife Ecology, Simon Fraser University, 8888 University Dr., Burnaby, BC, Canada V5A1S6

<sup>2</sup>Wildlife Research Division, Environment and Climate Change Canada, 5421 Robertson Rd., Delta, BC, Canada V4K3N2

<sup>3</sup>Department of Biology, Dalhousie University, 1355 Oxford Street, Halifax, NS, Canada B3H4R2

Understanding the fine-scale movements and habitat use patterns of marine predators is critical for identifying important foraging habitat and guiding effective conservation planning. Here, Global Positioning System (GPS) loggers were used to track chick-rearing Cassin's auklets (*Ptychoramphus aleuticus*) at their largest breeding colony, located on Triangle Island, British Columbia, Canada. Analyses were conducted at both the individual and population level to assess whether inter-annual variation in habitat use (2014, 2015, and 2017) could be explained by dynamic oceanographic features, such as sea surface temperature (SST) and chlorophyll *a* concentrations, or by static bathymetric features. At both scales of analyses, the foraging behaviour of Cassin's auklets was most strongly influenced by SST. At the individual level, birds spent more time foraging in areas with lower SST, relative to other areas visited over the course of a foraging trip. At the population level, the at-sea distribution of Cassin's auklets varied across years, with birds using areas northwest of colony in 2014 and areas west of the colony in 2015 and 2017. Furthermore, the probability of foraging across the study area was higher in areas with lower SST, suggesting that SST influences the broad-scale foraging distribution of Cassin's auklets. Identification of the environmental drivers of habitat use across multiple years can be used to help predict suitable at-sea habitat across time, leading to more effective conservation management.

#### PRELIMINARY EFFECTS OF THE 2016-2017 ERUPTIONS OF BOGOSLOF VOLCANO ON AT-SEA DENSITIES OF LOCAL SEABIRDS

Gary S. Drew (gdrew@usgs.gov)<sup>1\*</sup>, Nora Rojek (nora\_rojek@fws.gov)<sup>2</sup>, John F. Piatt (jfpatt@usgs.gov)<sup>1</sup>

<sup>1</sup>USGS Alaska Science Center, 4200 University Dr., Anchorage AK 99508

<sup>2</sup>USFWS Alaska Maritime National Wildlife Refuge, Homer AK 99603

Prior to its eruption on 12 December 2016, Bogoslof Island was a colony site for Fork-tailed Storm-petrels (*Oceanodroma furcata*), Glaucous-winged Gulls (*Larus glaucescens*), Kittiwakes (*Rissa spp.*), Murres (*Uria spp.*) and Tufted Puffins (*Fratercula cirrhata*). Repeated eruptions over the next eight months

reshaped the island, destroying vegetation and nesting habitat through the deposition of large quantities of ash and pyroclastic debris. The extended nature of the eruption as well as different species composition (primarily piscivores) differentiated this event from the recent Kasatochi Island eruption. Eruptions began prior to the 2017 nesting season and continued through to late August, and so we expected that some small amount of seabird mortality could be directly attributable to the eruptions. However, densities at sea for Tufted Puffin and Glaucous-winged Gulls did not indicate changes from a pre-eruption survey in 2012. In contrast, Kittiwake (spp.) densities were lower and Fork-tailed Storm-petrels disappeared completely. Murre (spp.) densities were unexpectedly higher following the eruption. We suspect this was due to failed or skipped nesting birds aggregating near the colony. No fledglings of any species were observed at-sea, though Glaucous-winged gull chicks were observed on land. The immediate aftermath of the 2016-2017 eruptions has led to a loss of two breeding seasons for local seabirds. However, like the planktivorous auklets on Kasatochi, most of the common piscivorous species at Bogoslof have displayed a strong site fidelity, limiting short-term changes in local abundances. Future surveys will allow us to separate the effects of nesting habitat and foraging resource limitations on these populations.

#### POST-RELEASE SURVIVAL OF OILED AND NON-OILED AQUATIC BIRDS REHABILITATED IN CALIFORNIA 1997-2011

Rebecca Duerr\* (rebecca.duerr@bird-rescue.org)  
Julie Skoglund (julie.skoglund@bird-rescue.org)  
Jay Holcomb<sup>†</sup>  
Michael Ziccardi (mhzziccardi@ucdavis.edu)

<sup>†</sup>International Bird Rescue, 4369 Cordelia Rd, Fairfield, CA 94534, USA

<sup>‡</sup>Karen C. Drayer Wildlife Health Ctr, One Health Institute, School of Veterinary Medicine, University of California, Davis, CA 95616, USA

International Bird Rescue has banded both oiled and non-oiled rehabilitated aquatic birds in California since the 1970s. We examined post-release re-encounter information from birds banded during 1997-2011, with resightings included through Oct 2017. Briefly, 23,061 bands were applied to 123 aquatic avian species, including 3998 petroleum oiled birds. There were 1,924 re-encountered individual birds from 58 species, including 205 petroleum oiled and 1718 non-petroleum oiled birds rehabilitated for

other reasons; 23.6% of re-encountered birds were alive at the most recent encounter. Time to re-encounter was compared by petroleum oiling status, species, year, age and sex (when available), and biomedical parameters. Data from petroleum oiled birds were directly compared to values reported in Sharp (1996) and showed 2.5- to 10-fold increases in mean time to re-encounter. Considering dead re-encounters alone, oiled birds showed significantly shorter time to re-encounter than non-oiled birds ( $p=0.0092$ ), but in California Brown Pelicans (*Pelecanus occidentalis californicus*) and Common Murres (*Uria aalge*), oiled birds showed longer intervals. Species was a highly significant factor in time to re-encounter, as was year of admission, body condition at arrival into care, and total plasma protein at release. With rare exception, all species included individuals surviving 2-14+ years after release. Live re-encounters of birds from this time period, especially from Brown Pelicans, continue to occur. This study presents data regarding post-release survival of rehabilitated birds and found marked improvement in post-release survival over previous studies. This project informs treatment and euthanasia guidelines during future oil spills.

#### ONCE AND FUTURE SEABIRDS OF HAWAII

David Cameron Duffy (dduffy@hawaii.edu)

Pacific Cooperative Studies Unit/Makamaka‘āinana, Department of Botany, University of Hawaii/Ke Kulanui o Hawai‘i, 3190 Maile Way, Honolulu Hawaii 96822 USA

The archipelago of Hawai‘i extends from Kure Atoll (28°24'N; 178°20'W) at the northwestern end of the chain, to the southernmost island of Hawai‘i (19°31'N; 155°30'W) 2,500 km away. Seabird breeding habitats range from sea level on northern islands to 3055 m on Haleakala Volcano, Maui. We do not know how many seabirds were present before the arrival of humans but with no mammalian predators on the only land masses in the North Central Pacific, the numbers must have been large. Polynesians arrived in Hawaii around 400 AD, with Europeans following in 1778. Direct harvesting for food and feathers, introduction of mammalian predators, land clearing, military bases, bombing and civilian disturbance must have greatly reduced or extirpated breeding populations. Today, the vast majority of Hawai‘i's seabirds nest on low-lying, predator-free islands in the Northwestern



Hawaiian Islands or on the islets and highlands of the larger islands. The islands now hold 22 species totaling approximately six million breeding individuals with a total population of fifteen million. Contemporary threats include human disturbance, plastics in the food chain, and introduced predators. Anthropogenic climate change in the form of sea level rise, increases in extreme rain events, and shifts in foraging areas present new challenges. Management began with the Native Hawaiians, but western-style conservation was begun by Teddy Roosevelt in response to uncontrolled plumage and egg exploitation, and continues by county, state, and federal agencies and NGOs. Today these agencies use predator control and eradication of predators on small offshore islands to protect surviving seabird populations. Increasingly exclusion of predators by fencing on larger islands and transplant of nestlings is being used to establish safe nesting areas on the larger islands. These exclosures may also become an effective response to loss of nesting habitat on low-lying islands because of sea level rise. Persistence of nesting seabird populations in Hawaii will require continued investment in management on land; however, changes in the marine environment and food supplies of Hawaiian seabirds may be of a scale that defies human intervention.

A MODEL TO ESTIMATE SEABIRD FIELD METABOLIC RATES

Ruth E Dunn ([ruth.dunn@liverpool.ac.uk](mailto:ruth.dunn@liverpool.ac.uk))\*, Jonathan A Green ([jagreen@liverpool.ac.uk](mailto:jagreen@liverpool.ac.uk)), and Craig R White ([craig.white@monash.edu](mailto:craig.white@monash.edu))<sup>‡</sup>

<sup>‡</sup> School of Environmental Sciences, University of Liverpool, Liverpool L69 3GP, UK

<sup>\*</sup> Centre for Geometric Biology, School of Biological Sciences, Monash University, Melbourne, Victoria 3800, Australia

For free-ranging animals, field metabolic rate (FMR) is the sum of their energy expenditure over a specified period. This quantity is a key component of ecological processes at every biological level. We applied a phylogenetically informed meta-analytical approach to identify the large-scale determinants of FMR in seabirds during the breeding season, utilising data from 64 studies of energetics in 47 species, and use these data to create a model to estimate FMR for any seabird population. We found that FMR was positively influenced by body mass and colony latitude and that it increased throughout the breeding season from incubation to brood to crèche. FMR was not impacted by colony-relative predation pressure or species average brood size. Based on this model, we present an app through which users can generate estimates of

FMR for any population of breeding seabird. We encourage the use of this app to complement behavioural studies and increase understanding of how energetic demands influence the role of seabirds as driving components of marine systems.

#### ORNITHOGENIC SOILS AS A LONG-TERM 'BIOLOGICAL ARCHIVE' OF ADÉLIE PENGUIN (*PYGOSCELIS ADELIAE*) TISSUES IN ANTARCTICA

Steven D. Emslie ([emslies@uncw.edu](mailto:emslies@uncw.edu))

University of North Carolina Wilmington, Department of Biology and Marine Biology, 601 S. College Road, Wilmington, NC USA 28403

Ornithogenic soils are common in coastal ice-free areas around Antarctica, especially those formed by the Adélie Penguin (*Pygoscelis adeliae*). Because of the dry, cold environment that characterizes east Antarctica and the Ross Sea, these soils can provide an archive of well preserved penguin tissues and prey remains that date from hundreds to thousands of years old. Mummified chick carcasses as well as penguin bones, feathers, skin, and eggshell fragments are recovered from these soils and available for a suite of analyses including radiocarbon dating, ancient DNA, stable isotopes, and most recently compound-specific stable isotope analysis of past diet and fluctuations in the marine environment. In addition, prey remains from guano including fish bones, otoliths, and squid beaks provide a sample of past marine conditions and sea surface temperatures. No other living seabird has such a long record of tissues in sedimentary deposits from the same region where that species occurs today. This unique record for the Adélie Penguin allows investigation of ecological responses to climate change over multiple major to minor climatic events over millennia. New results from the Ross Sea where this record extends to >45,000 years before present (B.P.) indicate frequent changes in colony distribution in relation to sea ice conditions and climate, and that most active colonies today are relatively young in age. Comparative studies of tissues from modern and museum specimens provide additional context to this long-term record.

## GENOME-WIDE DATA REVEAL THE DEEP EVOLUTIONARY HISTORY OF OCEANIC SEABIRDS (PROCELLARIIFORMES)

Andrea Estandia (andrea.estandia@durham.ac.uk)<sup>1,\*</sup>, R. Terry Chesser (CHESSERT@si.edu)<sup>2</sup>, Helen F. James (JAMESH@si.edu)<sup>3</sup>, Vincent Bretagnolle (Vincent.BRETAGNOLLE@cebc.cnrs.fr)<sup>4</sup>, Andreanna J. Welch (a.j.welch@durham.ac.uk)<sup>1</sup>

<sup>1</sup>Department of Biosciences, Durham University

<sup>2</sup>USGS Patuxent Wildlife Research Center

<sup>3</sup>National Museum of Natural History, Smithsonian Institution

<sup>4</sup>Equipe AGRIPOP, CEBC-CNRS

With a striking 600-fold difference in weight between its smallest and largest members, the order Procellariiformes—which encompasses petrels, storm petrels and albatrosses—is the most diverse among the oceanic birds; it is also one of the most threatened. Despite this, their molecular phylogeny remains unresolved. Previous order-wide studies have suffered from poor taxon sampling and lack of resolution due to the small amount of sequence data used—generally restricted to a single mitochondrial gene. We are using genome-scale nuclear DNA sequence data from 4365 loci in 53 species, representing all genera and major lineages, to build a phylogeny and examine the deep relationships within the order. We have confirmed that albatrosses are basal, and that the two lineages of storm petrels are not sister to each other. We also found that diving capacity has likely evolved more than once, with the diving petrels being nested within the Procellariidae but well separated from the other diving taxon, the shearwaters. Our future work will include representatives of all extant and recently extinct species to investigate how ecology has influenced divergence and examine characteristics that may be related to extinction risk.

## NEST SITE SELECTION AND REPRODUCTIVE SUCCESS IN A MIXED BREEDING COLONY OF CHINESE CRESTED TERNS AND GREATER CRESTED TERNS

Zhongyong Fan(fanzhy@zmnh.com)<sup>1</sup>, Xiao Zhou(zxycy1991@126.com)<sup>2</sup>, Yiwei Lu(luyw@zmnh.com)<sup>3</sup>, Daniel D. Roby(daniel.roby@oregonstate.edu)<sup>3</sup>, Donald E. Lyons(don.lyons@oregonstate.edu)<sup>4</sup>, and Shuihua Chen(chensh@zmnh.com)<sup>1,\*</sup>

<sup>1</sup>Zhejiang Museum of Natural History, Hangzhou, China

<sup>2</sup>Zhejiang Normal University, Jinhua, China

<sup>3</sup>Oregon Cooperative Fish and Wildlife Research Unit, Department of Fisheries and Wildlife, Oregon State University, Corvallis, Oregon, USA

<sup>4</sup>National Audubon Society Seabird Restoration Program, Corvallis, Oregon, USA

Nest site selection plays a critical role in reproductive success at seabird breeding colonies. Since 2013, we have conducted a tern restoration project at the Jiushan Archipelago in the East China Sea to establish a new breeding colony of Chinese Crested Terns (*Thalasseus bernsteini*) and Greater Crested Terns (*T. bergii*). To develop a mechanistic understanding of nest site selection and the causes of nesting failure in this mixed-species tern colony, we divided the colony site into 52 3m X 3m plots. In each plot we measured vegetation cover, slope, distance to the nearest audio playback speaker, and distance to the observation blind, factors that we suspected would influence tern nest site selection and breeding success. We then recorded the timing and rate of nest site occupancy and subsequent nesting success in each plot to test whether those factors influenced nest site selection and reproductive success. The results indicated that vegetation cover, distance to audio playback speaker, distance to the observation blind, and the number of other active nests in the plot had significant effects on nest site selection; terns tended to nest on plots with greater vegetation cover, less rock and bare soil cover, closer to audio playback speakers, and further from the observation blind. But plots with greater vegetation cover and greater slope had significantly lower nesting success. Our results suggest that by managing the nesting substrate, controlling vegetation growth, and keeping observation blinds a minimum distance from the colony site, more suitable nesting habitat could be provided and breeding success of the mixed-species tern colony could be enhanced.

## A CRITICALLY ENDANGERED SEABIRD SPECIES FAILS TO RESPOND TO ERADICATIONS OF MULTIPLE INVASIVE PREDATORS

Johannes H. Fischer (johannesfischer@live.nl)<sup>1,\*</sup>, Graeme A. Taylor (gtaylor@doc.govt.nz)<sup>2</sup>, Rosalind Cole (rcole@doc.govt.nz)<sup>3</sup>, Igor Debski (idebski@doc.govt.nz)<sup>2</sup>, Doug P. Armstrong (D.P.Armstrong@massey.ac.nz)<sup>4</sup>, and Heiko U. Wittmer (Heiko.Wittmer@vuw.ac.nz)<sup>1</sup>

<sup>1</sup> School of Biological Sciences, Victoria University of Wellington, PO Box 600, Wellington 6140, New Zealand.

<sup>2</sup> Aquatic Unit, Department of Conservation, PO Box 10420, Wellington 6143, New Zealand.

<sup>3</sup> Murikihu District Office, Department of Conservation, PO Box 743, Invercargill 9840, New Zealand.

<sup>4</sup> Wildlife Ecology Group, Massey University, Private Bag 11222, Palmerston North, New Zealand.

The eradication of invasive predators from islands is a common technique to safeguard seabird populations, but post-eradication monitoring of those species is often lacking. The Whenua Hou Diving Petrel (*Pelecanoides whenuahouensis*; WHDP) is a small, recently-described and 'Critically Endangered' Procellariiform seabird, currently restricted to Codfish Island (Whenua Hou). Invasive predators, considered the major threat to WHDP, were eradicated on Codfish Island in 2000; however, pre- or post-eradication estimates of WHDP population size and trends remain unknown, hindering assessments of the success of the eradications. To estimate population sizes, we collated simple intermittent field data (burrow counts [40 years] and capture-mark-recapture [CMR] data [16 years]) and retrospectively accounted for various sources of uncertainty. We then applied log-linear models to assess the population growth rate ( $\lambda$ ) before and after predator eradications. The WHDP population was estimated at 205 (184-226; CMR-based) adults in 2018. The pre-eradication  $\lambda$  was estimated at 1.022 (0.962-1.081; burrow-count-based), while the post-eradication  $\lambda$  was estimated at 1.018 (0.997-1.040; burrow-count-based) and 1.043 (1.018-1.068; CMR-based). These results indicate no apparent difference between pre- and post-eradication  $\lambda$ , in contrast with the responses of other (small) Procellariiformes. The lack of change between pre- and post-eradication  $\lambda$ , combined with the low post-eradication  $\lambda$ , indicates that other threats may be limiting WHDP population recovery. Our results illustrate that, contra prevalent assumptions, invasive predator eradications do not guarantee to recovery of remnant native populations. Provided historic data exists, we advocate the continuation of simple, albeit imperfect, monitoring methods, with retrospective corrections, to assess population recoveries.

## PRELIMINARY FINDINGS ON THE DIET OF LAYSAN ALBATROSSES, *PHOEBASTRIA IMMUTABILIS*, IN THE EASTERN BERING SEA AND ALEUTIAN ISLANDS REGION

Alphabetized by Fitzgerald and also alphabetized by Walker

William A. Walker (mindwalk@msn.com)<sup>1</sup>, Shannon Fitzgerald (shannon.fitzgerald@noaa.gov)<sup>2</sup>, Jessie Beck (jessie@oikonos.org)<sup>3</sup>, and Erica L. Donnelly-Greenan (donnellygreenan@gmail.com)<sup>3</sup>

<sup>1</sup> Marine Mammal Laboratory, Alaska Fisheries Science Center, NMFS, NOAA.

<sup>2</sup> Resource Ecology and Management Division, Alaska Fisheries Science Center, NMFS, NOAA.

<sup>3</sup> Oikonos Ecosystem Knowledge, Santa Cruz, CA.

Stomach contents were analyzed from 125 Laysan albatrosses, *Phoebastria immutabilis*, collected from the fisheries bycatch in the eastern Bering Sea and Aleutian Islands region during the years 2008 – 2017. Food items obtained from fisheries sources and from the natural environment were readily identifiable and are treated separately in the analyses. Twenty species scavenged from fisheries sources were present in 92 samples with an overall frequency of occurrence (FO) of 89.0 %. Of these, three species utilized as bait in the demersal longline fisheries; Argentine short-fin squid, *Illex argentinus*, Pacific saury, *Cololabis saira*, and Pacific herring, *Clupea pallasii*, were the most common with an FO of 46.0 %. The remaining 16 species had a collective FO of 78.6 % and were scavenged from trawl fisheries bycatch discards (offal). Within the naturally occurring diet component there were 28 species present with an overall FO of 96.1 %. Twenty-five species of mesopelagic squid made up the bulk of the naturally occurring diet with an overall frequency by number of 99.0 % and FO of 96.1 %. Fishes played a minor role in the natural diet with a frequency by number of only 0.9 % with an FO of 4.0 %. Of the naturally occurring food components, *Taonius borealis* dominated the diet making up by number 43.5 % followed by ten species of the family Gonatidae with a 29.3 % contribution by number. Collectively they dominated the natural diet with a contribution of 72.8% by number and occurrence of 89.3%. We see a distinct bias toward adult-size mesopelagic squid, revealing these were probably scavenged at the surface as dead or moribund.

PINCH POINTS AND SCALE: IMAGINING A NEW BIOGEOGRAPHY FOR SEABIRDS OF THE CENTRAL PACIFIC

Elizabeth Flint ([Beth\\_Flint@fws.gov](mailto:Beth_Flint@fws.gov))

US Fish and Wildlife Service, Marine National Monuments of the Pacific, 300 Ala Moana Blvd. Suite 5-231, Honolulu, Hawaii 96850 USA

Conservationists identify threats to wildlife and ecosystems, prioritize them, and manage them. Pelagic seabirds present a challenge to practitioners because their natural history includes both intense fidelity to nesting sites that may not vary more than a few meters during an individual's lifespan and vast foraging ranges that encompass entire hemispheric ocean basins. Both our scientific understanding of seabird biology and our ability to moderate threats from human-induced changes are influenced by our own limitations as terrestrial creatures in that we have learned much more about seabird behavior, physiology, and ecological vulnerabilities in the breeding colonies than we have in the oceanic habitats of these species. Human introductions of mammals to oceanic islands have determined the current breeding map of central Pacific seabirds because mammalian predation at the nest is a selective force that oceanic island breeders are unable to withstand. Existing breeding distributions are relicts of the spread of human commensal mammals starting a few thousand years ago. The realization that simply removing or excluding mammals from an area can restore seabird breeding, either with natural recolonization or by translocation, has opened up thrilling opportunities for us. The looming specter of climate change with its multiple overwhelming threats to seabirds on land and at sea has increased the urgency to use the tools of eradication, translocation, and assisted colonization in combination with our understanding of foraging habitat requirements more aggressively to assist as many species as possible through the rapid changes to come.

ETHNO-ORNITHOLOGY IN RAPA NUI (EASTER ISLAND): THE IMPORTANCE OF SEABIRDS FOR CONSERVATION AND LANGUAGE STRENGTHENING.

Marcelo Flores ([marcelo.flores@uandresbello.edu](mailto:marcelo.flores@uandresbello.edu))<sup>\*</sup>, Pedro Hito-Hito<sup>‡</sup>, Graciela Campbell<sup>‡</sup> ([gcampbellriro@gmail.com](mailto:gcampbellriro@gmail.com))<sup>‡</sup>, and Pedro Lazo ([pedro.lazo@conaf.cl](mailto:pedro.lazo@conaf.cl))<sup>‡</sup>

<sup>\*</sup>Departamento de Ecología y Biodiversidad. Facultad de Ciencias de la Vida. Universidad Andrés Bello, Santiago, Chile.

<sup>‡</sup>Corporación Nacional Forestal (CONAF) Rapa Nui

Coexistence of the human and bird dimension has rarely been considered in avian conservation, especially regarding the ancestral knowledge of native people. Rapa Nui has historically experienced multiple alterations of anthropic origin that led its people almost to extinction, the loss of both written language and their strong connection with nature, such as the Tangata manu ritual.

Today, oral communication from the older to younger generations is the only source of transmissional knowledge that evidences loss of ancestral cognition about biodiversity. This has led to the use of generic names for different wildlife groups, thus hindering species identification. In this sense, correct identification of species according to the original context and language is imperative to incorporate the local community in conservation tasks and the protection of Rapa Nui's natural heritage.

In recent years, we managed to create a database of local, common and scientific names. By incorporating children from schools, through talks and workshops, we have achieved that these names can be used regularly and transmitted to their families. In this way we contribute to the knowledge and identification of different species of seabirds, increasing their interest in this taxon and the Rapanui language. An example is the case of Tropicbirds (Tavake), having proposed new names that allow to differentiate the two species present on the island, such as Tavake hiku mea-mea for the Red-tailed Tropicbird (*Phaethon rubricauda*) and Tavake hiku tea-tea for the White-tailed Tropicbird (*P. lepturus*).

## DIVING DEPTHS OF CASSIN'S AUKLETS IN A CHANGING CLIMATE

Clare Flynn<sup>1</sup>\* ([clare.flynn@pomona.edu](mailto:clare.flynn@pomona.edu)), Pete Warzybok<sup>2</sup>, ([pwarzybok@pointblue.org](mailto:pwarzybok@pointblue.org)), Andre Cavalcanti<sup>1</sup>, ([andre.cavalcanti@pomona.edu](mailto:andre.cavalcanti@pomona.edu)), Nina Karnovsky<sup>1</sup>, ([nina.karnovsky@pomona.edu](mailto:nina.karnovsky@pomona.edu))\*\*, Jaime Jahncke<sup>2</sup> ([jjahncke@pointblue.org](mailto:jjahncke@pointblue.org))

<sup>1</sup>Pomona College, Department of Biology, 175 W. 6th St. Claremont, CA USA 91711

<sup>2</sup>Point Blue Conservation Science, 3820 Cypress Drive, Suite #11 Petaluma, CA USA 94954

Cassin's auklet (*Ptychoramphus aleuticus*) reproductive success has been monitored on Southeast Farallon Island (SEFI) for the past 47 years. Their annual productivity has varied with oceanographic conditions from years with 0 chicks raised (e.g. 2005 and 2006) to years with many double broods (e.g. 2010). Cassin's auklet reproductive success is dependent their ability to find high densities of zooplankton (primarily *Thysannoessa spinifera* and *Euphausia pacifica*) close to the colony during chick rearing. The purpose of this study was to understand how oceanographic conditions affect Cassin's auklet diving behavior. We hypothesized that lower upwelling and/or higher sea surface temperatures (SSTs) lead Cassin's auklets to dive to greater depths. We assumed that deeper dives reflect lower food availability and increased searching effort for prey. We deployed time depth recorders (TDRs) on 85 Cassin's auklets on SEFI from 2008-2017 for 268 foraging trips. We programmed the TDRs to record temperature and pressure every 5 seconds, and every 0.5 seconds when diving. We used the Pacific Fisheries Environmental Laboratory derived upwelling index (UI) from three months prior to the early chick-rearing season, and SST measured from SEFI during the days the TDRs were deployed. We found that in years with higher SSTs and in years with less upwelling, the Cassin's auklets made deeper dives. These results show that the physical conditions that drive the development of the California Current system food web influence the foraging behavior of top predators.

## A SPATIAL ASSESSMENT OF ALBATROSSES, FISHERIES, AND BYCATCH EVENTS IN COASTAL BRITISH COLUMBIA

Caroline Fox ([caroline.fox@canada.ca](mailto:caroline.fox@canada.ca))<sup>1</sup>\*, Colin Robertson ([colinr23@gmail.com](mailto:colinr23@gmail.com))<sup>2</sup>, Patrick O'Hara ([patrick.ohara@canada.ca](mailto:patrick.ohara@canada.ca))<sup>3</sup>, Rob Tadey ([robert.tadey@dfo-mpo.gc.ca](mailto:robert.tadey@dfo-mpo.gc.ca))<sup>4</sup>, Ken Morgan ([ken.morgan@canada.ca](mailto:ken.morgan@canada.ca))<sup>5</sup>

<sup>1</sup>Canadian Wildlife Service, Environment and Climate Change Canada, Pacific Wildlife Research Centre, 5421 Robertson Rd., Delta, BC, Canada, V4K 3N2.

<sup>2</sup>Department of Geography and Environmental Studies, Wilfrid Laurier University, 75 University Ave., Waterloo, ON, Canada, N2L 3C5.

<sup>3</sup>Canadian Wildlife Service, Environment and Climate Change Canada, Institute of Ocean Sciences, 9860 W. Saanich Rd., Sidney, BC, Canada, V8L 4B2.

<sup>4</sup>Fisheries and Oceans Canada, 401 Burrard Street, Vancouver, BC Canada, V6C 3S4.

A primary threat faced by the majority of the world's albatrosses is fisheries bycatch mortality. Although quantitative estimates of albatross bycatch are often unavailable due to a relative lack of monitoring, spatial overlap between fisheries and albatrosses is commonly used to estimate the extent of spatial interaction, a proxy for bycatch risk. Using records of commercial longline and trap fishing and survey information for albatrosses (Black-footed Albatross, *Phoebastria nigripes*; Laysan Albatross, *P. immutabilis*; Short-tailed Albatross, *P. albatrus*), the extent of spatial interaction was estimated in Canada's Pacific coast waters. Overall, the distributions of albatrosses and longline and trap fisheries were found to substantially overlap, with interaction hotspots concentrated along the continental shelf break. Trap fisheries reported only one albatross bycatch event, suggesting that these fisheries are responsible for negligible albatross mortalities despite substantial overlap. In contrast, >80% of recorded albatross bycatch events occurred within 10 km of longline fisheries-albatross hotspot locations, providing evidence that longline-albatross interaction hotspots and adjacent areas represent actual areas of elevated risk. Indicative of a potentially significant conservation concern, 45% of Short-tailed Albatross sightings occurred within 10 km, and 67% within 30 km, of longline-albatross interaction hotspots. Contributing knowledge regarding the extent of albatross-fisheries interactions, in addition to undertaking the first evaluation of albatross-fisheries hotspots with recorded bycatch events on Canada's Pacific coast, this

study informs albatross bycatch mitigation efforts in Canadian waters.

#### THE IMPACTS OF LIGHT POLLUTION ON WEDGE-TAILED SHEARWATERS ALONG SOUTHEASTERN O'AHU

Brooke Friswold(brookef@hawaii.edu)<sup>1,\*</sup>, Keith Swindle(keith\_swindle@fws.gov)<sup>2</sup>, David Hyrenbach(khyrenba@gmail.com)<sup>3</sup>, Tiana Bolosan(tiana.r.bolosan@hawaii.gov)<sup>4</sup>, Melissa Price(pricemel@hawaii.edu)<sup>1</sup>

<sup>1</sup>Natural Resource and Environmental Management, University of Hawai'i at Mānoa, 1910 East-West Road, Sherman Laboratory 101; Honolulu, HI 96822

<sup>2</sup>Hawai'i and Pacific Islands U.S. Fish and Wildlife Service, 300 Ala Moana Blvd, Honolulu, HI 96850

<sup>3</sup>Marine Conservation, Hawai'i Pacific University, 41-202 Kalaniana'ole Hwy, Waimanalo, HI 96795

<sup>4</sup>Offshore Management, Hawai'i Division of Forestry and Wildlife, Kalanimoku Building 1151 Punchbowl St. Room 325 Honolulu, HI 96813

The attraction to light was a previously beneficial behavior for seabirds. The invention of artificial light is now negatively impacting their survival due to distraction and disorientation, leading to fallout and often death. Hundreds of Wedge-tailed Shearwaters (*Ardenna pacifica*) experience fallout each fledging season across O'ahu, possibly due to artificial light pollution. We hypothesized the presence of artificial light was a significant factor contributing to fallout, and that fallout increased over time. From 2002 to 2010 standardized surveys were conducted on the Southeastern shore of O'ahu during the Wedge-tailed Shearwater fledging season (November-December). The location of downed birds as well as the presence or absence of an artificial light source or fallout factor within 25 feet was analyzed along transects. We employed spatial and temporal analyses to determine if a correlation existed between likelihood of fallout with presence of artificial light and other fallout factors. The effects of wind and power lines were also analyzed. We found that artificial light was present in 94% of recovered Wedge-tailed Shearwaters, power lines in 83% and that fallout has been steadily increasing over time despite some years of decline. This research suggests artificial lights are negatively impacting fledging seabirds; the most endangered taxonomic group. The results may be used to improve management of seabird colonies near urban areas and

to alleviate or influence human-induced effects. The information will assist with proactively resolving human-wildlife management across the state of Hawai'i concerning a federally protected species.

#### POSITIVE TRENDS IN RECRUITMENT AND REPRODUCTIVE SUCCESS OF 'UA'U (PTERODROMA SANDWICHENSIS) ON LEEWARD HALEAKALĀ

Martin Frye (mfrye@hawaii.edu)<sup>1,\*</sup>, George Akau(gakau@sempraglobal.com)<sup>2</sup>, Benjamin Campbell(bcampbell@sempraglobal.com)<sup>3</sup>, Jenni Learned(jlearnedj@hawaii.edu)<sup>1</sup>, Jay Penniman(jayfp@hawaii.edu)<sup>1</sup>

<sup>1</sup>Maui Nui Seabird Recovery Project, PO Box 903, Makawao, HI 96768

<sup>2</sup>Auwahi Wind Energy, PO Box 201364, Kula, HI 96790

The endangered 'Ua'u (Hawaiian petrel, *Pterodroma sandwichensis*) has suffered population decline due to habitat change and introduced alien mammals. The most significant remaining colony is located within Haleakalā National Park, with birds nesting in lower densities in surrounding buffer zones. Maui Nui Seabird Recovery Project works to protect 'Ua'u by monitoring burrows and controlling predators in Kahikinui Forest and Nakula Natural Area Reserves on the leeward slope of Haleakalā. Auwahi Wind Energy utilizes comparable methodology in the adjacent Kahikinui Petrel Management Area. We provide a combined analysis of recent trends in recruitment and demographic patterns across three buffer zone field sites using game camera, burrow activity, automated acoustic monitoring, and systematic ground search data.

We calculate reproductive success of 'Ua'u burrows (N=131) using two metrics: R1=fledged chicks/total active burrows; and R2=fledged chicks/breeding burrows. Results from R1 are low due to an increase in the number of prospecting birds. Results from R2 are increasing annually due to a relative increase in fledged chicks. Low R1 accompanied with increasing R2 rates are suggestive of a sub-colony in the early stages of recruitment via immigration. Birds may be recruiting into the study area from the larger colony within Haleakalā National Park, where predator control efforts and ungulate exclusion have been ongoing for decades. Automated acoustic monitoring and systematic ground search data within Kahikinui/Nakula support this interpretation of R1 and R2. Overall results indicate positive trends in

demographic composition of 'Ua'u sub-populations in the buffer zone around Haleakalā National Park.

#### BREEDING SEASON MOVEMENTS AND MARINE HABITAT USE BY THE MARBLED MURRELET (*BRACHYRAMPHUS MARMORATUS*) IN OREGON.

Garcia-Heras Marie-Sophie ([ms.garciaheras@oregonstate.edu](mailto:ms.garciaheras@oregonstate.edu))\*, Lindsay J. Adrean ([lindsay.adrean@oregonstate.edu](mailto:lindsay.adrean@oregonstate.edu)), S. Kim Nelson ([kim.nelson@oregonstate.edu](mailto:kim.nelson@oregonstate.edu)), Daniel D. Roby ([daniel.roby@oregonstate.edu](mailto:daniel.roby@oregonstate.edu)), Matthew G. Betts ([matt.betts@oregonstate.edu](mailto:matt.betts@oregonstate.edu)), and James W. Rivers ([jim.rivers@oregonstate.edu](mailto:jim.rivers@oregonstate.edu))<sup>1</sup>

<sup>1</sup>Department of Forest Ecosystems and Society, Oregon State University, Corvallis, Oregon, USA

<sup>2</sup>Department of Fisheries and Wildlife, Oregon State University, Corvallis, Oregon, USA

<sup>3</sup>US Geological Survey-Oregon Cooperative Fish and Wildlife Research Unit, Department of Fisheries and Wildlife, Oregon State University, Corvallis, Oregon, USA

<sup>4</sup>Forest Biodiversity Network, Department of Forest Ecosystems and Society, Oregon State University, Corvallis, Oregon, USA

Identifying habitat use and movement patterns during the breeding season is essential for effective conservation. The Marbled Murrelet (*Brachyramphus marmoratus*) is a threatened seabird in the Pacific Northwest region that forages in nearshore waters and nests in adjacent mature forest habitat. Despite its extensive geographic range, there are few data regarding movements and marine habitat use by this species. We captured at-sea and marked 137 adult Marbled Murrelets with VHF-telemetry tags during the 2017-2018 breeding seasons along the central Oregon Coast. Birds were monitored for  $59.6 \pm 29.5$  days during the breeding season (May-August) by conducting regular ground- and aerial-based telemetry surveys to relocate individuals along the coast. Overall, we collected >1100 GPS locations using aerial-based telemetry and >7300 bearings at ground-based telemetry stations. We found large differences in movements between the two study-years: in 2017, no birds were detected moving inland to nest and the majority of individuals dispersed long distances to the north or south, outside the 120-km core study area. In contrast, nesting was confirmed or likely for 11 individuals in 2018, with tagged birds clustering around specific marine areas and conducting shorter-distance movements. These inter-annual differences in

movements and nesting propensity were associated with differences in ocean conditions, ultimately affecting food availability for Marbled Murrelets. Our results highlight the importance of understanding how inter-annual variation in ocean conditions influences habitat use, movements, and breeding propensity to inform future effective conservation planning and management for this threatened seabird.

#### BEHAVIOURAL CLASSIFICATION IN SHALLOW DIVING SEABIRDS INDICATES NEW SEARCH BEHAVIOUR

Aran Garrod ([garrod.aran@s.nenv.k.u-tokyo.ac.jp](mailto:garrod.aran@s.nenv.k.u-tokyo.ac.jp))\*, Kentaro Sakamoto ([kqsakamoto@aori.u-tokyo.ac.jp](mailto:kqsakamoto@aori.u-tokyo.ac.jp)), Sei Yamamoto ([sei.y@aori.u-tokyo.ac.jp](mailto:sei.y@aori.u-tokyo.ac.jp)), Yoshinari Yonehara ([yonehara@aori.u-tokyo.ac.jp](mailto:yonehara@aori.u-tokyo.ac.jp)), Katsufumi Sato ([katsu@aori.u-tokyo.ac.jp](mailto:katsu@aori.u-tokyo.ac.jp))<sup>1</sup>

<sup>1</sup>University of Tokyo Graduate School of Frontier Sciences, 5 Chome-1-5 Kashiwanoha, Kashiwa, Chiba Prefecture, Japan 277-8561

The use of miniaturised data loggers for investigating at-sea behaviours in seabirds has uncovered greater detail about seabird movement and foraging. Behaviour can be classified using three-dimensional acceleration recorded by animal-borne tags. Classification of flapping and gliding phases in birds has improved knowledge of avian ecology, allowing estimates of energy usage and time budgets to be calculated. Similar behavioural derivation in deep diving seabirds has advanced the study of seabird foraging energetics. However, shallow diving seabirds provide a more complex challenge given the shorter and less distinct acceleration signals produced whilst surface diving. To improve description of shallow dive behaviour, 5 streaked shearwaters (*Calonectris leucomelas*) were fitted with video and acceleration data loggers (Little Leonardo, Tokyo). An algorithm to discern behaviours from these acceleration signals has been generated. Preliminary results indicate a previously unreported behaviour. Dive bouts were observed where birds made multiple landings to the sea surface in quick succession, typically taking off within 1-2 seconds. Acceleration signals of these intermittent take-offs differed from take-off signals when returning to transit flight. Further refinements in the interpretive algorithm will provide additional detail of this behaviour and provide better evidence of at-sea behaviours of shallow diving seabirds and our understanding of their energetics and foraging patterns.

## SOME IMPORTANT AND UNRESOLVED PROBLEMS IN SEABIRD SCIENCE

Anthony Gaston ([tonygastonconsult@gmail.com](mailto:tonygastonconsult@gmail.com))

Environment and Climate Change Canada, National Wildlife Research Centre, Carleton University, Ottawa, Ontario K1A 0H3, Canada

We can carry out research on most topics in zoology using seabirds as our subjects, but certain aspects of seabird research raise questions that are peculiar to marine ornithology as a sub-discipline. These questions mainly derive from the peculiarities of seabird biology, especially the 'seabird syndrome' of deferred reproduction, low fecundity, high survival and delayed senescence. These characteristics are all associated with a single feature of seabird ecology: foraging range during reproduction. The empirical observation that seabirds feeding far offshore have lower fecundity than those using inshore waters dates to David Lack in the 1950s. However, ideas on the contributing causes of the seabird syndrome are rarely explicitly proposed and even more rarely tested. I will examine those theories that do exist in the light of recent information relating to seabird foraging behaviour created by the deployment of tracking devices. I will also deal with some undescribed demographic consequences of the typical seabird life history strategy.

## UNRAVELING THE PACIFIC NORTHWEST RHINOCEROS AUKLET MORTALITY EVENT OF 2016

Thomas Good ([tom.good@noaa.gov](mailto:tom.good@noaa.gov))\*, Scott Pearson ([scott.pearson@dfw.wa.gov](mailto:scott.pearson@dfw.wa.gov)), and Peter Hodum ([peter@oikonos.org](mailto:peter@oikonos.org))<sup>‡</sup>

<sup>‡</sup>Northwest Fisheries Science Center, 2725 Montlake Boulevard East, Seattle, WA USA 98112

<sup>‡</sup>Washington Department of Fish and Wildlife, 1111 Washington St SE, Olympia, WA USA 98501

<sup>‡</sup>Biology Department, University of Puget Sound, 1500 N Warner St., Tacoma, WA USA 98416

Identifying causes of usual mortality events is critical to understanding marine ecosystem health. In the spring and summer of 2016, >400 dead Rhinoceros Auklets (*Cerorhinca monocerata*) washed ashore in the eastern Strait of Juan de Fuca and Puget Sound. Meanwhile, auklets on nearby Protection Island showed normal early breeding performance (burrow

occupancy, hatching success) but slow chick development and poor chick fledging success. Dead auklets examined by labs in the U.S. and Canada were emaciated and showed signs of pneumonia and septicemia. Breeding performance in 2017-2018 returned to long-term averages, except for extremely low burrow occupancy in 2017, a possible holdover effect. In 2016, auklet bill loads were considerably lighter, contained fewer fish, and contained less energy than other years. To explore which might have come first—emaciation or disease—we analyzed fish condition calculated from auklet diet data as well as from a 2016 Puget Sound trawl survey. Herring in the auklet diet in 2016 were smaller and in poorer condition than herring from trawl sampling, but both herring and sand lance condition in the auklet diet in 2016 did not differ from other years. Auklets may regularly select smaller and lower condition fish than available, as has been found elsewhere. Local environmental conditions and poor foraging conditions may have led to a pathogen outbreak, or immunocompromised auklets may have provisioned lighter and lower-energy bill loads, leading to poor reproductive performance. We are exploring factors such as contaminants and local environmental indicators to address this “chicken or egg” conundrum.

## SEX RATIO IS VARIABLE AND INCREASINGLY MALE-BIASED AT TWO COLONIES OF MAGELLANIC PENGUINS

Natasha Gownaris\* ([ngownaris@gmail.com](mailto:ngownaris@gmail.com)) and Dee Boersma ([boersma@uw.edu](mailto:boersma@uw.edu))

<sup>‡</sup>Department of Biology and Center for Ecosystem Sentinels, University of Washington, Seattle, WA, 98103

Sex ratios are commonly skewed and variable in wild populations, but few studies track temporal trends in sex ratio. We examined sex ratio patterns at two breeding colonies of Magellanic penguins (*Spheniscus magellanicus*) in Chubut, Argentina. Penguins from both colonies spend the non-breeding season at sea and oceanographic conditions during this period disproportionately influence female survival and skipped breeding rates. We predicted similar trends in sex ratio at these breeding colonies (Prediction 1) driven by variation in the number of females returning (Prediction 2), poorer female reproductive performance in years when fewer females returned to breed (Prediction 3), and more male fights and lower male breeding rates in years when sex ratio was more male-biased (Prediction 4). We found support for all



but Prediction 3. Interannual variation in female reproductive performance was uncorrelated with sex ratio, possibly because females breeding in years of low female return rates are of high quality. Because non-breeders influence colony dynamics and because ignoring skewed sex ratios can mask population declines, effective conservation of wild populations requires tracking adult sex ratios.

#### MAPPING CONSENSUS ON GLOBAL MARINE PRIORITY REGIONS: IMMEDIATE OPPORTUNITIES FOR FUTURE PROTECTION

Gownaris, N.J.\* ([ngownaris@gmail.com](mailto:ngownaris@gmail.com)), Pikitch, E.K.<sup>2,3</sup> ([ellen.pikitch@stonybrook.edu](mailto:ellen.pikitch@stonybrook.edu)) Santora, C.M.<sup>2,3</sup> ([christine.santora@stonybrook.edu](mailto:christine.santora@stonybrook.edu)), Davis, J.<sup>4</sup> ([john@octogroup.org](mailto:john@octogroup.org))

<sup>1</sup>Department of Biology and Center for Ecosystem Sentinels, University of Washington, Seattle, WA, 98103

<sup>2</sup>School of Marine and Atmospheric Sciences, Stony Brook University, Stony Brook, NY, 11794

<sup>3</sup>Institute for Ocean Conservation Science, Stony Brook University, Stony Brook, NY, 11794

<sup>4</sup>Open Communications for the Ocean, Woodinville, WA, 98072

To effectively safeguard biodiversity, marine protected areas (MPAs) must be placed using the best available science. There are numerous ongoing United Nations and nongovernmental initiatives to map global marine priorities, but they have never been considered in sum. Using a spatial meta-analysis of ten such initiatives, we highlight important but unprotected areas of the ocean. We found that 55% of the ocean has been identified as a priority region by at least one initiative and that as many as seven initiatives overlap in a region. The selection criteria used by these initiatives vary greatly. Unprotected regions identified by two to four initiatives cover 12.5% of the ocean and represent excellent opportunities for future MPAs. Regions with five or more overlapping initiatives are largely within MPAs already, lending support to our approach to highlighting priority regions. We found that 10% of nearly every EEZ lies in identified but unprotected regions and that there are many global opportunities for large (>100 km<sup>2</sup>) to very large (>100,000 km<sup>2</sup>) new MPAs. Our simple yet novel analysis represents an immediate and powerful tool to examine areas of importance for new MPAs.

#### ASSESSMENT OF PERSISTENT, BIOACCUMULATIVE AND TOXIC SUBSTANCES (PBTS) IN BLACK-TAILED GULL EGGS FROM SOUTH KOREA

Gi Myung Han ([gmhan@kiost.ac.kr](mailto:gmhan@kiost.ac.kr))\*, Sang Hee Hong ([shhong@kiost.ac.kr](mailto:shhong@kiost.ac.kr))<sup>1,2</sup>, Won Joon Shim ([wjshim@kiost.ac.kr](mailto:wjshim@kiost.ac.kr))<sup>1,2</sup>, Mi Jang ([jangmi@kiost.ac.kr](mailto:jangmi@kiost.ac.kr))<sup>1,2</sup>, You Na Cho ([cyn625@kiost.ac.kr](mailto:cyn625@kiost.ac.kr))<sup>1,2</sup>, Sung Yong Ha ([syha@kiost.ac.kr](mailto:syha@kiost.ac.kr))<sup>1</sup>

<sup>1</sup>Oil and POPs Research Group, Korea Institute of Ocean Science and Technology, Geoje 53201, Republic of Korea

<sup>2</sup>Department of Marine Environmental Sciences, Korea University of Science and Technology, Daejeon 34113, Republic of Korea.

Eggs have been used successfully as a non-destructive monitoring tool for persistent organic pollutants (POPs) and heavy metals. Seabird eggs have long been used as biomonitors for long-term monitoring of environmental contaminants in the Europe and North America. In South Korea, national monitoring program on environmental contaminants has been run primarily for coastal sediment and bivalves, while biomonitoring program for high-tropic marine species such as marine mammals and seabirds has not been established yet. The purpose of this study was to monitor seabird eggs inhabiting along the Korean coasts to identify the levels and profiles of contaminants. Black-tailed gull eggs were collected from breeding places located in the southern (Hongdo Island), eastern (Dokdo Island), and western (Seomando Island) coasts of South Korea and egg content was used for chemical analysis. Among the target analytes, PCBs and DDTs showed highest levels at all sites, indicating their great bioaccumulation and biomagnification potential. The concentrations of PBDEs and HBCDs in eggs were found to be relatively higher at Seomando compared to other two sites and the levels of PCBs and OCPs were similar among locations. The concentrations of PBDEs and HBCDs were still lower than PCBs and DDTs, but relatively higher than other POPs. The relatively persistent isomers or congeners of each compound such as p,p'-DDE,  $\beta$ -HCH, BDE-47,  $\alpha$ -HBCD were dominantly accumulated in seabird eggs compared to in their preys. Key-word: seabird, egg, persistent organic pollutants, biomonitoring.

## BYCATCH OF BANDED SEABIRDS IN THE PACIFIC OCEAN, 1945-2018

Autumn-Lynn Harrison ([HarrisonAL@si.edu](mailto:HarrisonAL@si.edu))\* and Sarah Poulin ([sarah.poulin@duke.edu](mailto:sarah.poulin@duke.edu)):

<sup>1</sup>Smithsonian Migratory Bird Center, National Zoological Park and Conservation Biology Institute, Washington, D.C., USA

<sup>2</sup>Marine Geospatial Ecology Lab, Nicholas School of the Environment, Duke University, Beaufort, North Carolina, USA

The use of leg bands on seabirds to provide knowledge of longevity, fidelity, connectivity, and impacts has a more than 80-year history in the Pacific Ocean. Today, most band encounters are reported electronically, however, letters, postcards, and forms were historically sent. For seabirds incidentally caught by fisheries, paper records often included information that was never entered electronically into the North American bird banding database including fishery type, name and flag state of the vessel, and sometimes, personal stories. We reviewed North American electronic encounter records of banded, incidentally caught seabirds in the Pacific Ocean spanning 1945-2018 (>10,000) to summarize longitudinal and geographic patterns in reported fishery encounters with banded birds. To provide further insights on the fisheries themselves, we also transcribed information from relevant USGS scanned and paper files (n=271) and cards in the archives of the Pacific Ocean Biological Survey Program at the Smithsonian Institution (n=35). Black-footed Albatross (*Phoebastria nigripes*, 56%), Laysan Albatross (*Phoebastria immutabilis*, 40%), and Wedge-tailed Shearwater (*Puffinus pacificus*, 2%) were the most frequently reported species. Longitudinal and colony-specific patterns in reported bycatch were evident. Fishing vessels used ten gear types, targeted at least 11 fish species, and originated from eight countries with Japanese and United States vessels accounting for over half of available records. Ninety vessel names were extracted from the records, primarily of Japanese tuna fishing vessels and U.S. government ships and including one U.S. whaling boat. This information will be presented together with examples of the colorful stories contained within the archives.

## USING SEQUENCE CAPTURE AND ILLUMINA SEQUENCING FOR POPULATION GENOMICS IN SEABIRDS

Michael G. Harvey ([mgh272@gmail.com](mailto:mgh272@gmail.com)):\*

<sup>1</sup>Dept. Of Ecology and Evolutionary Biology, 430 Hesler Hall, University of Tennessee, Knoxville, TN 37996

With the advent of short read sequencing technology, it is now feasible to obtain DNA sequences from across the genomes of many individuals. Still unclear, however, is which set of genomic markers to use and what wet lab approach is best for subsampling whole genomic DNA. Seabirds pose particular challenges because they breed in scattered and remote locations that are difficult to reach for obtaining fresh samples, necessitating the combination of samples from sources like blood, feathers, muscle tissue, or skin at various stages of degradation. A laboratory method called sequence capture uses custom RNA probes to extract genomic regions of interest and works well with all manner of samples, even highly degraded material. RNA probes designed to target conserved genomic regions can be used to obtain data from thousands of loci in any seabird species without any prior knowledge of their genomic makeup. I will provide a complete overview of sequence capture and Illumina sequencing including sampling strategies, laboratory equipment and methods, and best practices for downstream bioinformatics and analysis. Presentation material will be paired with an online tutorial on the platform Github that can be used by researchers for assembling their own data. I will discuss the applications of this approach to a range of studies on seabird systematics, ecology, and conservation.

## AT-SEA FLOCK SIZE OF SEABIRD IN THE NORTHERN BERING SEA

Haruka Hayashi ([omurice.555@gmail.com](mailto:omurice.555@gmail.com))\*, Bungo Nishizawa<sup>1</sup>, Nodoka Yamada<sup>1</sup>, Charlie Wright<sup>2</sup>, Toru Mukai<sup>1</sup>, Toru Hirawake<sup>1</sup>, Yutaka Watanuki<sup>1</sup>

<sup>1</sup>Graduate School of Fisheries Sciences, Hokkaido University, 3-1-1 Minato-cho, Hakodate, Hokkaido, 041-8611, Japan

<sup>2</sup>Washington Cooperative Fish & Wildlife Research Unit, US Geological Survey, Seattle, WA, USA

Seabirds may vary their flock size according to their prey abundance. We conducted boat-based seabird

observations concurrently with acoustic survey (fish and zooplankton biomass) and CTD measurements in the northern Bering Sea during July 2018. We defined “seabird flock” as the distance between nearest individuals <10 m. For Short-tailed shearwater *Puffinus tenuirostris* (STSH) and Murres *Uria* spp. (MURRE), the size of flying and feeding flocks were not different. The sizes of flying flocks of Crested auklet *Aethia cristatella* (CRAU; 5.2 birds/flock) and Least auklet *Aethia pusilla* (LEAU; 5.3) were larger than these of feeding flocks (CRAU 3.2, LEAU 3.0), while opposite trend was observed in Northern Fulmer *Fulmarus glacialis* (NORF; Flying 1.2, Feeding 4.7). NORF may search prey individually, while auklets do with flocks. Flock size of foraging CRAU and LEAU were largest in Bering Shelf Water where zooplankton biomass was the largest, while density of CRAU and LEAU were highest in Anadyr Water (AW). Flock size of foraging MURRE and NORF were largest in AW where fish biomass was highest, while flock size of foraging STSH was highest in Alaskan Coastal Water where prey biomasses were lowest. Our study indicates that seabird flock size may vary depending on their foraging type (i.e. surface feeders or divers) and/or prey biomass.

#### NORTH PACIFIC PELAGIC SEABIRD DATABASE V3 – DATA COMPILATION EFFORT TO FACILITATE SPATIAL AND TEMPORAL ANALYSES OF AT-SEA MARINE BIRD SURVEYS IN THE NORTH PACIFIC

Brielle Heflin ([bheflin@usgs.gov](mailto:bheflin@usgs.gov))<sup>1\*</sup>, Gary Drew ([gdrew@usgs.gov](mailto:gdrew@usgs.gov))<sup>2</sup>, Mayumi Arimitsu ([marimitsu@usgs.gov](mailto:marimitsu@usgs.gov))<sup>1</sup>, and John Piatt ([jpiatt@usgs.gov](mailto:jpiatt@usgs.gov))<sup>2</sup>

<sup>1</sup>USGS Alaska Science Center, 250 Egan Drive, Juneau, AK USA 99801

<sup>2</sup>USGS Alaska Science Center, 4210 University Drive, Anchorage, AK USA 99508

The North Pacific Pelagic Seabird Database (NPPSD) is currently the largest single source of data on seabirds at-sea in the North Pacific. The NPPSD v2, currently available online, contains at-sea survey data collected between 1973 and 2012. Data from a wide variety of researchers and organizations were binned into transects (most ~3-4 km), standardized, reformatted, and compiled to create the NPPSD. The database has been used by various investigators to map seasonal distribution and abundance of marine birds, investigate seabird energetics, identify important bird areas, and to assess status and trends of threatened

species. We are currently compiling data for the NPPSD v3, which will include more recent (2013-2018) at-sea surveys of marine birds in the Gulf of Alaska, Aleutian Islands, and the Bering, Chukchi and Beaufort seas, and from locations beyond Alaska including Canada, Russia and the U.S. Pacific Coast. With collaborators at the Bureau of Ocean Energy Management (BOEM), the NPPSD v3 will be used to model and map the distribution and abundance of common seabirds that use U.S. territorial waters off Alaska. In collaboration with partners at the National Marine Fisheries Service (NMFS), we will also compile data on the distribution of key forage species (e.g., sand lance, capelin, age-0 pollock) in Alaska from several available fisheries databases. This effort is also supported by BOEM to evaluate potential risks to fish and wildlife in oil and gas development areas.

#### PHYLOGEOGRAPHY OF A WIDESPREAD SEABIRD (ARDENNA PACIFICA) USING GENOME-WIDE MARKERS

Rachael Herman ([rachael.herman@stonybrook.edu](mailto:rachael.herman@stonybrook.edu))\*, Donna Dittman<sup>‡</sup>, and Michael Harvey<sup>§</sup>

<sup>\*</sup>Stony Brook University, Stony Brook, NY USA 11794

<sup>‡</sup>Louisiana State University, Baton Rouge, LA USA 70803

<sup>§</sup>University of Tennessee Knoxville, Knoxville, TN USA 37996

Pelagic seabirds are highly mobile, reducing opportunities for population isolation that might promote differentiation and speciation. At the same time, many species are philopatric, and their tendency to return to their natal islands to breed may reduce gene flow sufficiently to permit local adaptation and differentiation. There are few well-sampled studies of geographic patterns of genetic differentiation in seabirds, partly due to a shortage of fresh genetic samples from their remote breeding locations. Museum specimens provide a ready source of DNA from otherwise un-sampled regions and even degraded material can be sequenced using new sequence capture methods. We studied the phylogeography of a widespread seabird, the Wedge-tailed Shearwater (*Ardenna pacifica*), using a sequence capture approach. We sampled *A. pacifica* from throughout its distribution, using a combination of tissue samples, blood, and toepads from museum specimens. We successfully recovered data from all samples, representing a total of 2,402 loci from across the genome containing 20,780 SNPs. There are no deep

divergences within *A. pacifica*, however a principle component analysis of genotypes identified modest differentiation among breeding areas. This differentiation was sufficient for assigning individuals sampled away from breeding areas to their likely source populations. Estimated Effective Migration Surfaces (EEMS) reveal reduced migration between the Indian Ocean and Pacific Ocean, presumably due to land barriers, and across the equator in the Pacific Ocean, perhaps due to differences in breeding schedule. Our results highlight the potential of sequence capture methods for genetic studies in species for which recent samples are not widely available.

#### REPORT ON THE SEABIRD RECOVERY EFFORT ON DESECHEO ISLAND, PUERTO RICO

Also alphabetized by Spatz

Jose Luis Herrera (jose.herrera@islandconservation.org)<sup>1</sup>, Cielo Figuerola (cielo.figuerola@islandconservation.org)<sup>1</sup>, Susan Silander (susan\_silander@fws.gov)<sup>2</sup>, Coral Wolf (coral.wolf@islandconservation.org)<sup>1</sup>, Dena Spatz (denarspatz@gmail.com)<sup>1\*</sup>, Nick Holmes (nick.holmes@islandconservation.org)<sup>1</sup>

<sup>1</sup>Island Conservation, 2100 Delaware Ave, Santa Cruz CA 95060

<sup>2</sup>U.S Fish and Wildlife Service – Caribbean National Wildlife Refuge Complex, PO Box 510, Boqueron, Puerto Rico 00622-0510

\*Presenting Author

On Desecheo Island National Wildlife Refuge, Puerto Rico, the introduction of invasive mammals such as feral goats, cats, black rats and rhesus macaques, as well as the use of the island as a bombing range, has nearly extirpated all seabird species that once regularly bred on the island. Restoring the island ecosystem has been a clear goal for US Fish and Wildlife Service, with emphasis on native seabirds, endemic reptiles and threatened plants. In 2017, after 10+ years of significant effort, Desecheo was declared free of invasive mammals, providing a foundation to begin additional restoration action for native species. Working with U.S Fish and Wildlife Service, we examined the historic breeding distribution of seabirds on the island, then applied that knowledge to the planning and implementation of a social attraction project for Bridled Tern (*Onychoprion anaethetus*) and Audubon's Shearwater (*Puffinus lherminieri*) in 2018.

Here we report on promising preliminary results after the first year of observation.

#### LIVING WITH SEABIRDS IN A COMPLEX LANDSCAPE: JUAN FERNÁNDEZ ISLANDS, CHILE

Alphabetized by Hester

Peter Hodum (peter@oikonos.org)<sup>1</sup>, Héctor Gutiérrez (hgutierrez@oikonos.org)<sup>1</sup>, Pablo Manriquez (pmanriquez@oikonos.org)<sup>1</sup>, Paola González (paola@oikonos.org)<sup>1</sup>, Valentina Colodro (valentina@oikonos.org)<sup>1</sup>, Michelle Hester (michelle@oikonos.org)<sup>1\*</sup>, Ryan Carle (ryan@oikonos.org)<sup>1</sup>

<sup>1</sup>Oikonos Ecosystem Knowledge, Valparaíso, Chile

The Juan Fernández Islands, a Chilean national park and UNESCO International Biosphere Reserve, are home to six breeding species of seabirds, four of which are globally listed as Vulnerable by IUCN. In addition, the waters of the archipelago are used by dozens of other seabird species. Importantly, the islands are also home to a community of approximately 900 people. Given the anthropogenic threats to the archipelago's seabirds, lasting conservation actions require the engagement, commitment and support of the local community. This presents both a challenge and an opportunity. We have intentionally engaged the local community for nearly 20 years to build local capacity, increase commitment to act and help change values required for long-term conservation efforts. Several priority conservation actions have required us to overcome initial resistance from various stakeholders in the community. To build support for the construction of fences to protect seabird breeding colonies from non-native mammal species, including cattle (*Bos taurus*) and European rabbits (*Oryctolagus cuniculus*), we worked closely with the cattlemen's association on the island. This collaboration resulted in their interest in building additional fences to improve pasture for cattle. The installation of seabird-friendly lights in key neighborhoods required that we develop close relationships with residents in the neighborhoods. A free workshop on seabird identification and biology that we offered to island residents increased community capacity to use seabirds as an economic resource through pelagic birding trips and guided visits to breeding colonies. Establishing partnerships and trust relationships is paramount to long-term conservation efforts.

## NON-BREEDING SEASON DISTRIBUTIONS AND THEIR RELATIONSHIP TO POPULATION GENETIC STRUCTURING IN THE RHINOCEROS AUKLET

Mark Hipfner (mark.hipfner@canada.ca)<sup>1,\*</sup>, Katie Studholme (krstudholme@dal.ca)<sup>2</sup>, Marie Prill (prill@uleth.ca)<sup>3</sup>, Alice Domalik (adomalik@sfu.ca)<sup>4</sup>, Strahan Tucker (strahan.tucker@dfo-mpo.gc.ca)<sup>5</sup>, Mark Drever (mark.drever@canada.ca)<sup>1</sup>, Glenn Crossin (glenn.crossin@dal.ca)<sup>2</sup>, and Theresa Burg (theresa.burg@uleth.ca)<sup>3</sup>

<sup>1</sup>Wildlife Research Division, Environment and Climate Change Canada, 5421 Robertson Rd., Delta, BC, Canada V4K 3N2

<sup>2</sup>Department of Biology, Dalhousie University, Halifax, NS, Canada B3H 4R2

<sup>3</sup>Department of Biology, University of Lethbridge, Lethbridge AB, Canada T1K 3M4

<sup>4</sup>Centre for Wildlife Ecology, Simon Fraser University, 8888 University Dr., Burnaby, BC, Canada V5A 1S6

<sup>5</sup>Fisheries and Oceans Canada, Pacific Biological Station, Nanaimo BC, Canada V9T 6N7

One of the leading hypotheses to explain the extent of population genetic structuring in seabirds revolves around their non-breeding season distributions: species with multiple non-breeding areas are expected to exhibit structuring. We set out to test this hypothesis, and to document variation in migratory behavior, in the Rhinoceros Auklet (*Cerorhinca monocerata*). To do this, we deployed light-level geolocator tags on auklets breeding on 13 Northeastern Pacific Ocean colonies – three in Alaska, six in British Columbia, two in Washington State, and two in California – and collected blood samples from untagged auklets on colonies spanning the North Pacific. We detected significant genetic structuring, especially between the eastern Pacific (North America) and western Pacific (Japan), but also a complex pattern within the eastern Pacific. There was marked individual variation in migratory behavior, from local residency around breeding colonies to long-range dispersal, but contrary to our hypothesis, inter-colony overlap was extensive; some individuals from all colonies spent winter in common areas. Further research will be needed to explain population genetic structuring in this species, a process that will aid conservation efforts.

## BREEDING COLONY PREDATION AND REPRODUCTIVE SUCCESS IN LEACH'S STORM-PETRELS (*OCEANODROMA LEUCORHOA*)

Rielle Hoeg (riellehoeg@acadiau.ca)<sup>1,\*</sup>

<sup>1</sup>Acadia University, 15 University Avenue, Wolfville, NS, Canada, B4P 2R6

Many seabirds nest on islands to avoid mammalian predators, and some nest underground and move to and from colonies at night to avoid diurnal avian predators. I am investigating the length of time that carcasses remain before disturbance (residence time) and predation rates in Leach's storm-petrels (*Oceanodroma leucorhoa*), a colonial seabird that nests underground on offshore islands. Trail cameras were used to monitor petrel carcasses and determine scavenger type. Five 2-meter wide transects were monitored approximately biweekly on Bon Portage Island, Nova Scotia, Canada, with one or more transects being monitored on other Atlantic Canadian colony islands, such as in Nova Scotia, Newfoundland and Labrador, and New Brunswick. Leach's storm-petrel carcasses, as well as gull and owl pellets, were counted and removed from transects on each visit, with pellets being collected for content analysis. Analyses are underway.

## NESTLING OF SEAGULL AS AN INDICATOR OF RECENT CHEMICAL CONTAMINATION IN THE MARINE ENVIRONMENT

Sang Hee Hong (shhong@kiost.ac.kr)<sup>1,2,\*</sup>, Gi Myung Han (gmhan@kiost.ac.kr)<sup>1</sup>, Mi Jang (jangmi@kiost.ac.kr)<sup>1,2</sup>, Won Joon Shim (wjshim@kiost.ac.kr)<sup>1,2</sup>, Sung Yong Ha (syha@kiost.ac.kr)<sup>1</sup>, Miran Kim (mirankim@knps.or.kr)<sup>3</sup>

<sup>1</sup>Oil and POPs Research Group, Korea Institute of Ocean Science and Technology, 391 Jangmok-myon, Geoje 656-834, South Korea

<sup>2</sup>Korea University of Science and Technology, Daejeon 305-320, South Korea

<sup>3</sup>Korea National Park Research Institute, South Korea

Seabirds can be useful indicators for current contamination and long-term trends in the marine environment. To investigate the contamination status and accumulation characteristics of persistent organic contaminants, eggs and dead nestlings (ages: < one week, about three weeks, > one month) were collected from a breeding site of black-tailed gulls located in the

southern part of Korea. In addition, dead adult gulls were collected nearby coastal regions. The egg content and liver tissues of nestling and adult gulls were subjected to the analysis of persistent organic pollutants including polychlorinated biphenyl (PCBs), organochlorine pesticides (DDTs, HCHs, chlordans and hexachlorobenzene), polybrominated diphenyl ethers (PBDEs), and hexabromocyclododecanes (HBCDs). The concentration of contaminants in nestling was highest immediately after hatching (< one week) due to maternally deposited contaminants in eggs, then rapidly declined as nestling grew (three weeks and one month of age). It is likely due to dilution of contaminant body burden through growth in size (namely, bio-dilution effect). Overall, isomeric (or congener) compositions were similar across all age groups with the high abundance of persistent isomer (or congener) of each compound such as PCB-153,  $\beta$ -HCH, DDE, PBDE-47, and  $\alpha$ -HBCD. It is interesting to note that  $\gamma$ -HBCD and BDE-209 that are dominant components of PBDDE and HBCD commercial mixtures, respectively, but less bioaccumulative and less persistent in the environment were detected in all sample groups, implying the recent use of those flame retardants. Moreover, the proportion of  $\gamma$ -HBCD was enhanced as nestling grew after hatching (10% in egg to 31% in nestling), which is likely related to the high abundance of  $\gamma$ -HBCD in anchovy (their potential prey) collected nearby the breeding site.

Adult bird integrates a long-term environmental contamination, while nestlings may represent recent and local contamination because chicks are fed with prey collected within a few kilometers of the nesting colony.

#### EFFECTS OF AGING ON THE FORAGING BEHAVIOR OF A LONG-LIVED SEABIRD IN GALÁPAGOS

Jennifer L. Howard (howajl14@wfu.edu)\*, Felipe A. Estela (felipe.estela@gmail.com)‡, David J. Anderson (da@wfu.edu)‡

‡Department of Biology, Wake Forest University, Winston-Salem, NC 27109, USA.

‡Departamento de Ciencias Naturales, Físicas y Matemáticas, Pontificia Universidad Javeriana - Cali, Valle del Cauca, Colombia

Although growing evidence indicates that actuarial and reproductive senescence are universal in long-lived vertebrates, the underlying processes remain elusive. Foraging across a wide area searching for

unpredictable prey is energetically costly. Therefore, a decline in physiological ability with age may manifest in various aspects of foraging behavior, and be an important mechanism for senescence. Our long-term study of Nazca boobies (*Sula granti*) on Isla Española, Galápagos, Ecuador, with known-aged individuals, allows us to evaluate the relationship between age and foraging performance in a long-lived bird. We tested the hypothesis that specific foraging parameters (i.e., trip distance and duration, forager's weight change, and core foraging areas) change with age in Nazca boobies. Foraging data were collected during the incubation period in five seasons: 2011-2012 and 2014-2016. GPS units were deployed on adult males and females of ages that fell between transitions in reproductive success: young (5-7 years), middle-aged (12-14), old (18-20), and oldest (21+) age groups. We extracted parameters from foraging tracks using continuous time movement models that accounted for autocorrelation and variation in sampling frequency. We used mixed-effects models with Age, Sex, and Body Size as fixed effects and Bird (individual from band number) and Year as random effects to evaluate any relationship with foraging behavior as measured by GPS loggers. Preliminary results indicate age-related variation in the use of tail winds during the return to the colony post-foraging trip.

#### MARINE PROTECTED AREAS (MPAs), OCEAN WILDERNESS AND SEABIRDS OFF NORTHERN PAPUA NEW GUINEA (PNG): MULTI-YEAR SURVEYS, SOCIO-ECONOMICS AND ECOLOGY

Falk Huettmann (fhuettmann@alaska.edu)\*

‡EWHALE lab- Inst. of Arctic Biology, Biology & Wildlife Dept. University of Alaska Fairbanks AK UAS 99775

Papua New Guinea (PNG) is world-renowned for its ocean wilderness but it's also known to be driven by international fisheries and mining. Humans lived in the area for over 30,000 years and subsistence lifestyles still dominate. However, many of the marine details are poorly known and the region remains widely unprotected. Here I show results and real-world socio-economic insights from over three years of field surveys -beach and marine- of northern Papua New Guinea (covering the coast and reefs for the area Sepik River -Manang - Lae). This area is known to feature a high diversity of tropical seabirds -some endemic others migratory. A connection with the North American Pacific exists (e.g. El Nino, migratory sea

turtles) and the occurrence of wintering Aleutian terns (*Onychoprion aleuticus*) is suspected but remains unconfirmed. I present how the findings relate to the Convention of Migratory Species (CMS, Bonn Convention) and what climate change will predict in the light of ongoing MPA work. I am concluding with elaborations on 'ridge to reef' work, the world seabird colony registry, GBIF and MOVEBANK as being indicative for such wilderness regions and their wider sustainability.

#### DEVELOPING ECOSYSTEM METRICS OF PLASTIC INGESTION BY MAIN HAWAIIAN ISLAND SEABIRDS

David Hyrenbach (khyrenbach@hpu.edu)\* and Michelle Hester (michelle@oikonos.org)‡

‡Marine Science Program, Hawai'i Pacific University, Waimanalo, HI 96795 USA

‡Oikonos Ecosystem Knowledge, Kailua, HI 96795, USA

Since 2009, we have studied marine plastic debris ingestion in seabirds from the Main Hawaiian Islands to assess community-wide patterns in locally-breeding species and to develop local pollution metrics. Between 2009 and 2018, we have necropsied over 1000 birds of 12 species and have documented ingestion in 7 species, belonging to 4 families (Diomedidae, Hydrobatidae, Procellariidae, Phaethontidae) and representing a variety of foraging guilds. We have documented low levels of plastic ingestion in White-tailed Tropicbirds, and Newell's Shearwaters (< 50% incidence); high levels (50 – 75 % incidence) in Hawaiian Petrels and Wedge-tailed Shearwaters; and very high levels (> 75 % incidence) in Band-rumped Storm-petrels, Bulwer's Petrels, and Laysan Albatross. In particular, we propose that the Wedge-tailed Shearwater (*Ardenna pacifica*) is an ideal bioindicator species of plastic in the epipelagic food web. During the breeding season, this species forages in association with subsurface-predators near their nesting colonies, is characterized by high rates of plastic ingestion in chicks (72.5%) and adults (71.4%), and can be readily sampled opportunistically by salvaging fledging chicks and accidentally-killed adults. To place the plastic ingestion data of these "tuna-birds" in a broader ecological context, we quantified the ingestion rates for island-associated predatory fishes caught by pole-and-line fishers around the Main Hawaiian Islands, and documented plastic ingestion in five species (mahi-mahi, albacore tuna, skipjack tuna, yellowfin tuna, and kawa-

kawa). Together, these results underscore the value of seabirds as bio-indicators of marine plastic pollution, within a broader framework incorporating information from other pelagic predators and their shared prey.

#### HUMAN PRESENCE NEAR WEDGE-TAILED SHEARWATER BURROWS AND ITS IMPACT ON NESTING SUCCESS

Jessica L. Idle (jidle@hawaii.edu)<sup>1\*</sup>, Brooke M. Friswold (brookef@hawaii.edu)<sup>1</sup>, Kristen C. Harmon (kmcory@hawaii.edu)<sup>1</sup>, Melissa R. Price (pricemel@hawaii.edu)<sup>1</sup>

Natural Resource and Environmental Management, University of Hawai'i at Mānoa, 1910 East-West Road, Sherman Laboratory 101, Honolulu, HI 96822

Due to previous management actions such as predator control and outplanting of native plants on O'ahu's offshore islets, Wedge-tailed Shearwater (*Ardenna pacifica*, WTSH) populations have increased to the point that new WTSH colonies have formed on O'ahu coastal areas. While there is limited human access to most of the offshore islets of O'ahu, a beach such as Kailua Beach Park with unrestricted access and where new WTSH colonies are forming was hypothesized to have significantly lower nesting success compared to beaches that have little to no human activity. Nesting success, nest-site characteristics, and human presence data was collected from occupied WTSH nests at a high human activity area, Kailua Beach Park, and minimal human activity area, the Marine Corps Base Hawai'i - Kāne'ohe Bay. The Mayfield Method was utilized to calculate nesting success. Human activity was recorded as the amount of human presence within five meters of the burrow over a five-minute period of time. Using a chi-square test, WTSH nesting success was significantly different between the two study sites. Wildlife managers can utilize this result to make decisions regarding protection of nesting seabirds on public beaches.

#### SEARCHING FOR ECOLOGICAL HISTORY IN OLD BONES AND FEATHERS

Helen James (jamesh@si.edu)\*

National Museum of Natural History, Smithsonian Institution, Washington, DC, 20013-7012

Range shifts of pelagic species and other rapid ecological changes in the oceans are expected due to warming sea surface temperatures, exacerbated by the ongoing effects of industrial fishing and perhaps by anthropogenic nutrient enrichment. Some seabird populations will respond by successfully shifting their diets and distributions, but others will decline (or in many cases continue to decline) in numbers. It is well-recognized that many species of pelagic seabirds also face ongoing threats on land. This talk will highlight the value of the extended timelines and baseline ecological data that can be recovered from archived materials, specifically from subfossil and archaeological bones and museum specimens, for documenting and understanding these phenomena. For pelagic seabirds in Hawaii, subfossil bones show that many species' breeding distributions have contracted but that relatively few extinctions have occurred, a cause for optimism about the ability of these birds to elude extinction. Ancient DNA and stable isotopes preserved in the old bones can provide baseline data on historical population structure, and on stability vs. change in foraging habits across millennia. Stable isotopes from feathers sampled from museum study skins provide a way to detect change across decades in seasonal foraging habits, going back as many as 150 years. Species with sequential molt of flight feathers can be sampled in a way that enables study of change in the level of individual foraging specialization within a population, on a centennial timescale. Seabird biologists have an opportunity to preserve fresh samples every year, to extend these valuable historical timelines into the future.

#### CRYPTIC SEABIRD MORTALITY ON U.S. WEST COAST PACIFIC HAKE FISHING VESSELS

Jason E. Jannot (jason.jannot@noaa.gov)\*, Tom Good (tom.good@noaa.gov), Vanessa Tuttle ([vanessa.tuttle@noaa.gov](mailto:vanessa.tuttle@noaa.gov))

Northwest Fisheries Science Center, NOAA, Seattle, WA USA

Seabirds of conservation concern, including three species of albatross, occur on the US west coast and interact with the Pacific hake at-sea catcher processor vessels using midwater trawl nets. Seabird mortalities caused by striking trawl warps and cables is a known source of cryptic mortality in trawl fisheries, resulting in underestimates of seabird bycatch in trawl fisheries. Fishery observers do not routinely monitor cables for seabird interactions and thus witness few seabird

cable strikes. Trawl nets and cables rarely capture injured or dead birds. Our goal was to identify and quantify the magnitude of seabird cable strikes on these vessels. Each observer monitored randomly selected cables at randomly selected times and documented strikes for two entire fishing seasons (2016-17). Observers also recorded variables associated with bird strikes, including strike type (hard vs. light), vessel operations, environmental conditions, and local bird abundance. All strikes (100%) occurred when offal discharge from the vessel was present. Hard strike rates were higher on vessels when a fish meal plant was operating. Observers witnessed 12 (2016) and 3 (2017) hard strikes of black-footed albatross (*Phoebastria nigripes*). We estimate that there were 394 ( $\pm 95\%$  CL: 32-811; 2016) and 101 ( $\pm 95\%$  CL: 29-183; 2017) hard cable strikes of this species during these two fishing seasons respectively. In contrast, fishery observers on these vessels only documented two (2016) and one (2017) black-footed albatross carcasses, suggesting a potential bias in black-footed albatross mortality estimates in this fishery. We will discuss on-going partnerships with industry to develop mitigation strategies and improve data collection.

#### MODELING THE WINTER HABITAT USE AND MORTALITY RISKS OF CASSIN'S AUKLETS (*PTYCHOGRAMMUS ALEUTICUS*) AND PIGEON GUILLEMOTS (*CEPPHUS COLUMBA*) IN THE NORTH PACIFIC

Michael E. Johns (mjohns@pointblue.org)<sup>1,2</sup>, Pete Warzybok (pwarzybok@pointblue.org)\*, Jaime Jahncke (jjahncke@pointblue.org)<sup>1</sup>, Mark Lindberg (mslindberg@alaska.edu)<sup>1</sup>, Greg Breed (gabbreed@alaska.edu)<sup>1</sup>

<sup>1</sup>Department of Biology and Wildlife and Institute of Arctic Biology, University of Alaska Fairbanks, PO BOX 756100, Fairbanks, AK 99775, USA

<sup>2</sup>Point Blue Conservation Science, 3820 Cypress Drive, Suite 11, Petaluma, CA 94954, USA

For seabirds with seasonal reproductive patterns, conditions experienced during the non-breeding winter months can be the most limiting. Reduced prey, severe weather, and an increased risk of oil spill exposure from shipping traffic can all lead to a greater risk of mortality. Advances in animal tracking technologies have revealed much about the winter distribution of marine top predators, allowing researchers to make inferences on habitat use and



environmental hazards during this critical period. Using archival light sensing tags, or geolocators, we aim to characterize the non-breeding range of Cassin's auklets and pigeon guillemots from Southeast Farallon Island, two species for which we have limited information on non-breeding movements. A total of 123 tags were deployed on Cassin's auklets from 2015-2018, and 60 tags on pigeon guillemots from 2017-18. Position estimates from raw light-level data were calculated with the R package "FlightR". With these movement data, step selection functions and conditional logistic regression were applied to model habitat use, and identify important environmental covariates that best describe their winter movement patterns. Cassin's auklets dispersed further from the island during periods of warmer than average sea surface temperatures, likely searching for frontal regions with high productivity. Pigeon guillemots, in contrast, migrated north to British Columbia following the breeding season, concentrating inside of Haida Gwaii. We would like to use this method to model dispersal patterns of Alcids throughout their range, and predict how threats from climate change and potential oil spills will influence future movement patterns and survival rates for these and other species.

#### SEABIRD RESPONSES TO INVASIVE MAMMAL REMOVAL AND THEIR INFLUENCE ON TERRESTRIAL AND NEARSHORE ISLAND ECOSYSTEM RECOVERY

Holly P. Jones\* (hjones@niu.edu), Stephanie Borrelle (stephborrelle@gmail.com),  
Lyndsay Rankin (lyndsyrankin@gmail.com), Christy N. Wails (wailsn@gmail.com)

<sup>1</sup>Northern Illinois University Department of Biological Sciences and Institute for the Environment, Sustainability, and Energy. 155 Castle Dr., DeKalb, IL 60115, USA

<sup>2</sup>University of Toronto Department of Ecology and Evolutionary Biology, 25 Wilcocks St, Toronto, ON M5S3B2, Canada

Seabirds are integral to terrestrial and nearshore ecosystem functioning on and around the islands on which they breed. However, invasive mammal introduction on seabird islands has resulted in reduction, extirpation, and even extinction of some seabirds. This fundamentally alters island and nearshore ecosystems, through the reduction in seabird-derived nutrient inputs and in biopedturbation and disturbances associated with breeding activity. We have been studying island responses to seabird recovery following invasive

mammal removal globally, with in-depth findings from New Zealand for nearly a decade. Our global analysis looks at seabird responses to invasive mammal removal documented on islands globally as revealed through a systematic review. In New Zealand, we collected museum and field specimens, and used stable isotopes and soil nutrient measurements to gauge island response to seabird recovery in a chronosequence of times since mammal removal, and compared those values to invaded and never invaded islands. To understand historical baselines, we used museum specimens to gauge seabird-derived nutrient cycling before mammal eradications for some islands. We are quantifying intra- and inter-specific seabird competition via nest site and foraging partitioning between seabird species recolonizing an island following mammal eradication. Lastly, we experimented with the potential of using drone imagery to remotely quantify seabird nutrient influence in island food webs. Our global analysis showed over half of critically endangered and nearly three quarters of endangered seabird species likely benefited from mammal eradication. In New Zealand, we find that island size could play a critical role in the extent of seabird influence into nutrient cycling; larger islands do not exhibit strong seabird-derived nutrient influences compared to smaller islands, suggesting there may be unexpected outcomes for ecosystem responses despite seabird recovery. We find seabirds are spatially partitioning their niches interspecifically and hypothesize they may intraspecifically partition dietary niches. In the nearshore environment, we find that algal community structure and nitrogen content is influenced by invasion histories: nearshore habitats appear more similar to never invaded islands as time since eradication increases. Lastly, we find drone imagery is promising for gauging seabird influence on islands remotely but that more research is necessary to understand the potential for this application at scale. We emphasize the importance of understanding how seabird influence changes with time since mammal removal, and when and where active seabird restoration may be necessary to spark ecosystem recovery.

#### ESTIMATES OF NEWELL'S SHEARWATER (*PUFFINUS NEWELLI*) AND HAWAIIAN PETREL (*PTERODROMA SANDWICHENSIS*) ABUNDANCE AND DISTRIBUTION BASED ON DATA COLLECTED AT SEA, 1998-2017

Trevor W. Joyce (trevorwjoyce@gmail.com)\*, Robert L. Pitman (robert.pitman@noaa.gov)<sup>1</sup> and Lisa T. Ballance (lisa.ballance@noaa.gov)<sup>1,2</sup>

Southwest Fisheries Science Center, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, 8901 La Jolla Shores Drive, La Jolla, CA 92037, U.S.A.

Scripps Institution of Oceanography, University of California San Diego, 9500 Gilman Drive, La Jolla, CA 92093, U.S.A.

Colony-based estimates of Newell's Shearwater (*Puffinus newelli*) and Hawaiian Petrel (*Pterodroma sandwichensis*) abundance have to-date been hindered by nocturnal colony attendance patterns, cryptic nesting strategies, and inaccessible breeding habitats, forcing a reliance on at-sea estimates dating to the 1980s-1990s (e.g., Spear *et al.* 1995). Here we present updated model-based estimates of abundance for these two endangered, endemic Hawaiian seabirds based on at-sea surveys in the Central and Eastern Tropical Pacific. Strip transect survey data was collected aboard National Oceanic and Atmospheric Administration (NOAA) research cruises during 13 field seasons over the period 1998 to 2017 and covered a substantial portion of marine habitats for each species. Species distribution and density models were developed using zero-inflated negative binomial (ZINB) generalized additive models (GAM), which allowed the simultaneous overdispersion of counts and extra zeros in the strip transect sampling process. Summing ZINB GAM predicted counts within our sampling domain yielded an estimate of 65,856 *P. sandwichensis* with the central 95th percentile of a non-parametric bootstrap distribution surrounding this estimate ranging from 19,717 to 91,097. A ZINB GAM for *P. newelli* yielded an estimate of 28,779 with a bootstrap 95th percentile range of 17,574 - 43,011. Neither estimate encompassed the entire at-sea range of either species and thus should be interpreted as minima of global average populations during our sampling period 1998-2017. Despite this limitation these estimates still provide valuable information in evaluating extinction risk, assessing conservation status, and setting recovery targets.

#### USE OF ACOUSTIC RECORDING DEVICES TO DIRECT SEABIRD MONITORING AND CONSERVATION EFFORTS ON THE ISLAND OF LĀNA'I, HAWAII.

Elizabeth C. Kain (Lkain@pulumalanai.com)\*, Rachel S. Sprague (rsprague@pulumalanai.com), André F. Raine (araine@hawaii.edu), Megan Vynne (mvynne@hawaii.edu), Scott Driskill (spdriskill@gmail.com)

Pūlama Lāna'i Department of Natural Resources, 1311 Fraser Ave., P.O. Box 630310, Lanai City, HI 96763

Kaua'i Endangered Seabird Recovery Project, 3900 Hanapepe Rd, Hanapepe, HI 96716

To monitor and protect endangered species, researchers need to gather accurate information on population size, population trends and breeding distribution. However in Hawai'i, the terrain that some of these species inhabit, coupled with some of their natural history characteristics, make direct observation challenging. For Hawaii's nocturnal seabirds, the use of automated acoustic recording devices ("song meters") has revolutionized the way in which monitoring and conservation efforts take place. They have allowed researchers to gather important information about distribution and relative density, while limiting the amount of disturbance on sensitive native habitat and the need for personnel to be in remote and potentially dangerous terrain at night. On the island of Lāna'i, we used song meters at 30 locations between 2015 and 2017 to survey 376 hectares of the approximate 606 hectares of remained native mesic forest on Lāna'i. We analyzed recordings from three endangered seabird species: Hawaiian petrels (*Pterodroma sandwichensis*), Newell's shearwaters (*Puffinus newelli*), and Band-rumped storm-petrels (*Oceanodroma castro*). We show how the use of song meters has given us important insights into relative density, phenology, and specific locations upon which to focus and prioritize our management, monitoring, and protection efforts.

#### COLLECTING FEATHERS AND CREATING KAHILI AS HAWAIIAN CULTURAL PRACTICE

Shad Kane ([shadskane@gmail.com](mailto:shadskane@gmail.com))\*

Daughters of Hawai'i, Queen Emma Summer Palace  
2913 Pali Hwy, Honolulu, HI 96817

Kahili are feathered standards that are important symbols of Hawaiian ali'i (royalty). During the monarchy period kahili served as a royal standard for a king or queen. Anciently it defined a level of governance. The highest rank chiefs made their kahili of seabird feathers while lesser rank chiefs made them from forest bird feathers. During ancient times chiefs would have their kahili precede them; it announced their presence and allowed people time to prostrate themselves. If they did not, they would be executed. In

modern times, most feather workers make kahili or kahili pa'alima using chicken or goose feathers (as native birds are protected). Few are able get access to seabird feathers; those that do get them from dead seabirds on Midway Island where the birds unfortunately die as a result of birds ingesting trash and plastics floating on our oceans. In 2012 the Daughters of Hawaii (DOH) and the Queen Emma Summer Palace needed new kahili made of traditional feathers. Since there was an interest in partnering with Native Hawaiian Cultural Practitioners, Queen Emma Summer Palace and the Office of Hawaiian Affairs (OHA) provided a grant for a trip to Midway. With the assistance of staff from the U.S. Fish and Wildlife Service, we were able to gather bodies of mōli (Laysan Albatross, *Phoebastria immutabilis*) chicks. As sad as the death of these birds was, we were able to use their feathers to create new kahili. To us, their feathers gave the birds a new way of flying again.

#### DECOMPOSING AGE-SPECIFIC REPRODUCTIVE PERFORMANCE IN A META-POPULATION OF ADÉLIE PENGUINS: COLONY SIZE MATTERS.

Peter Kappes (peter.kappes@oregonstate.edu)<sup>1\*</sup>, Katie Dugger (katie.dugger@oregonstate.edu)<sup>2</sup>, Amélie Lescroël (alescroel@pointblue.org)<sup>3,4</sup>, David Ainley (dainley@penguinscience.com)<sup>5</sup>, Grant Ballard (gballard@pointblue.org)<sup>6</sup>, and Phil Lyver (LyverP@landcareresearch.co.nz)<sup>6</sup>

<sup>1</sup>Oregon Cooperative Fish and Wildlife Research Unit, Department of Fisheries and Wildlife, Oregon State University, Corvallis, OR 97331, USA

<sup>2</sup>U.S. Geological Survey, Oregon Cooperative Fish and Wildlife Research Unit, Department of Fisheries and Wildlife, Oregon State University, Corvallis, OR 97331, USA

<sup>3</sup>Point Blue Conservation Science, Petaluma, CA 94954, USA

<sup>4</sup>Centre d'Ecologie Fonctionnelle et Evolutive, UMR 5175, CNRS - Université de Montpellier - Université Paul-Valéry Montpellier - EPHE, Montpellier 3, France

<sup>5</sup>H.T. Harvey & Associates Ecological Consultants, Los Gatos, CA 95032, USA

<sup>6</sup>Manaaki Whenua Landcare Research, Lincoln 7640, New Zealand

Age-specific reproductive performance is well-documented in long-lived seabirds. Determining mechanisms that produce these patterns is difficult because contributing processes may operate at both the individual- (within-individual change) and population-level (selective appearance and

disappearance). By decomposing these processes we documented the relative contribution of each process to age-specific breeding performance of Adélie penguins (*Pygoscelis adeliae*) at three different-sized colonies. To our knowledge this is the first study to consider age-specific performance at multiple colonies. Overall improvement in performance was due to both selective disappearance and within-individual improvement at the two smaller colonies, and exclusively the latter at the largest colony. Relative contribution varied by colony relative to life stage, with similar contributions early in life at each colony, but important differences between the smaller and largest colonies late in life. Late-life performance at the two small colonies was primarily driven by population-level changes as individuals that had lower reproductive performance disappeared, while within-individual improvement and disappearance of individuals of high reproductive performance both contributed at the largest colony. These results indicate tradeoffs associated with different life history strategies and colony size, and highlight the need to account for different processes that could contribute to age-specific reproductive performance. In addition, incorporating replication relative to multiple colonies highlights the variation in age-specific performance that can occur within a meta-population.

#### KAWAIOLOA CEREMONY ("WATER IS LIFE")

Sabra Kauka ([sabra@ischool.org](mailto:sabra@ischool.org)) Hawaiian Studies Kumu at Island School & DOE Hawaii

To start off the PSG2019 conference, we have a very special event for everyone. Kumu Sabra Kauka will hold a *Kawaiola* ceremony (*Water is Life*) for all attendees of the Welcome Reception at 18:00 sharp in the Jasmine Ballroom.

##### What is a Kawaiola Ceremony?

*The ceremony has been created to acknowledge the importance of fresh water to all life and to increase everyone's awareness about where their water comes from. On Kaua'i we are blessed with fresh water, in our rain and in our streams. In fact, the Hawaiian definition of wealth is 'wai wai', which amply highlights the importance of water – if you have an abundance of fresh water, you have wealth.*

##### What do you have to do to take part?

- Attendees should bring a small amount of fresh water (a thimble full) from their home country. For attendees from Hawaii, bring

fresh water from your study site or management area.

- Water should be collected from a spring or direct fresh water source (not from a tap!).
- For those coming from overseas please boil your water before transporting it to Kaua'i to prevent any bugs from making the trip with you!
- It is really important that we know how many people are going to bring water with them, so please email André at araine6@hawaii.edu if you intend to directly take part in this. Let André know where your water will come from! If we do not hear from you by FEBRUARY 24<sup>th</sup> we will assume you aren't taking part.

#### What will happen during the Kawaiola Ceremony?

- Everyone will gather in the Jasmine Ballroom, with those presenting water seated in the reserved section up front.
- *Kani Ka Pu* - sounding of the conch at the front of the conference hall. This announces the beginning of the welcoming ceremony.
- *Oli Aloha* - welcoming chant and introductions.
- *Ho Mai Ka Wai* - Participants will bring their water up to the front, say their name and the location where the water came from, then place the water in the collecting bowl.
- *Ho'opomaika'i Me Ka Wai* - Water blessing.
- *O Kau Ola* - Closing chant asking for long life.

After the ceremony is over, there will then be a hula (the *Pule Ho'āla "O Nā Kumu Akua* with Kehaulani Kekua and Halau Palaihiwa O Kaipuawai), followed by a presentation by Kumu Sabra.

#### RED-THROATED LOON WINTER HABITAT CHARACTERISTICS

Nicole Kleponis ([nicolekleponis@gmail.com](mailto:nicolekleponis@gmail.com))\*

Delaware State University, 1200 N Dupont Hwy,  
Dover, DE 19901

The Red-throated Loon is listed in the North American Waterbird Conservation Plan as the highest conservation priority among waterbirds in the U.S. Northeast and mid-Atlantic Region, covering Massachusetts, Connecticut, Rhode Island, New York, New Jersey, Delaware, and Maryland. Studies have shown that the densest wintering populations of the

Red-throated Loon in the east Atlantic are in Delaware Bay and off of North Carolina. There are few studies on the habitat requirements of where Red-throated Loon winters, and those few indicate there is some variation in habitat choice. It is unknown if the Red-throated Loon chooses specific habitat characteristics or if they are highly adaptable. I am conducting shoreline point count surveys along the Delaware side of the bay to identify the relationship between loon abundance and habitat characteristics. I have point counts at thirteen locations along the Delaware side of Delaware Bay and three along the Atlantic Coast of Delaware Bay. In my analysis, I will focus on the Red-throated Loon, but will record other members of Gaviidae (loons), Podicipedidae (grebes), Anatidae (ducks and geese), and Laridae (gulls and terns). I hypothesize that salinity is the most important factor, affecting the amount of prey that are available, and that there will be more Red-throated Loons found in areas of high salinity.

#### ENGAGING PILOTS TO PROTECT SEABIRD COLONIES ON THE CALIFORNIA COAST: LESSONS LEARNED FROM TEN YEARS OF OUTREACH AND EDUCATION

Wendy E. C. Kordesch ([wendy.kordesch@noaa.gov](mailto:wendy.kordesch@noaa.gov))\*, Paul S. Hobi ([paul.hobi@noaa.gov](mailto:paul.hobi@noaa.gov)), Karen Reyna ([karen.reyna@noaa.gov](mailto:karen.reyna@noaa.gov)), Gerard J. McChesney ([gerry\\_mcchesney@fws.gov](mailto:gerry_mcchesney@fws.gov)), Cassie M. Bednar ([cassie.bednar@humboldt.edu](mailto:cassie.bednar@humboldt.edu)), and Richard T. Golightly ([richard.golightly@humboldt.edu](mailto:richard.golightly@humboldt.edu))<sup>‡</sup>

<sup>‡</sup>Seabird Protection Network, Greater Farallones National Marine Sanctuary, San Francisco, California 94129 USA.

<sup>‡</sup>U.S. Fish and Wildlife Service, San Francisco Bay National Wildlife Refuge Complex, Fremont, California 94555 USA.

<sup>‡</sup>Humboldt State University, Dept. of Wildlife, Arcata, California 95521 USA.

One challenge in addressing human disturbance to seabirds is a lack of awareness of the problem. This challenge is exacerbated when human interactions are indirect, as is the case with pilots who fly over the coast unaware of seabird colonies below. At Devil's Slide Rock near Pacifica, California, monitoring since 2005 has shown that a colony of Common Murres (*Uria aalge*) consistently experiences greater levels of human disturbance from aircraft than other monitored colonies in the region. The Seabird Protection Network, a program aimed at reducing human disturbances to breeding seabirds, has

conducted outreach, education and enforcement efforts informed by a long term monitoring project (known as the Common Murre Restoration Project). Here, we provide insight into how working directly with stakeholders (pilots, airport management) has improved our efforts to engage target audiences and allowed us to forge successful partnerships with local airports and pilot communities. Examples of widely applicable environmental behavior change design methods and lessons learned from trial and error in communication strategy will be discussed.

#### DIFFERENTIAL RESPONSE OF GULF OF MAINE SEABIRDS TO THE 2018 OCEAN HEAT WAVE

Stephen Kress ([skress@audubon.org](mailto:skress@audubon.org))\*, Don Lyons ([dlyons@audubon.org](mailto:dlyons@audubon.org)), Paula Shannon ([pshannon@audubon.org](mailto:pshannon@audubon.org))<sup>1</sup>

<sup>1</sup> National Audubon Society Seabird Restoration Program, 159 Sapsucker Woods Road, Ithaca, NY 14850 USA

<sup>2</sup> National Audubon Society Seabird Restoration Program, 104 Nash Hall, Corvallis, Oregon 97330 USA

<sup>3</sup> National Audubon Society Seabird Restoration Program, 12 Audubon Road, Bremen, ME 04551 USA

Seabirds nesting in the Gulf of Maine (GOM) are dependent on abundant and accessible forage fish during summer months to feed and fledge young. Previously, anomalously warm years (e.g., 2012 and 2013) have been associated with reduced productivity for seabird species in the GOM. During the summer of 2018, GOM sea surface temperatures (SST) varied dynamically between long-term average levels and daily maximums not seen in the last two decades. In particular, in early August daily mean SST exceeded the long-term average by >4°C and previous daily maximums by >2°C. This thermal event (ocean heat wave) apparently had significant impacts on the distribution and potentially the abundance of forage fish in the Gulf. We saw a variable response among different seabird species, with impacts related to breeding biology and foraging mode. Razorbill (*Alca torda*) nesting success was least impacted, presumably due to their early fledging (mid-July) and capacity for deep diving where they can find herring and other forage fish seeking cooler temperatures. Common Tern (*Sterna hirundo*) nesting was heavily impacted, consistent with their surface foraging mode and need to finish raising chicks during late July and early August. Puffin (*Fratercula arctica*) chick growth slowed considerably during the thermal event and

many chicks died, but those that survived received ample feedings during a return to more moderate conditions in later August and many ultimately fledged at normal mass. The puffin's capacity to defer migration and extend their chick-rearing season proved advantageous. These observations suggest that the timing of even short-term thermal events, and the capacity of individual species for adaptive behavioral compensation, will play large roles in determining which seabird species persist in a warming Gulf of Maine.

#### SEABIRD BYCATCH AND MITIGATION EFFORTS IN ALASKA FISHERIES SUMMARY REPORT: 2007 THROUGH 2017

Joseph R. Krieger, Ph.D. ([joseph.krieger@noaa.gov](mailto:joseph.krieger@noaa.gov))\*, Jennifer Roberts ([jennifer.roberts@noaa.gov](mailto:jennifer.roberts@noaa.gov)), Shannon M. Fitzgerald ([shannon.fitzgerald@noaa.gov](mailto:shannon.fitzgerald@noaa.gov)), Anne Marie Eich, Ph.D. ([annemarie.eich@noaa.gov](mailto:annemarie.eich@noaa.gov))<sup>1</sup>

<sup>1</sup> NOAA National Marine Fisheries Service Alaska Region, 709 W. 9<sup>th</sup> St. Juneau, AK. 99802

<sup>2</sup> NOAA National Marine Fisheries Service Alaska Fisheries Science Center, 7600 Sand Point Way N.E., Building 4, Seattle, Washington 98115

Fishermen sometimes catch and discard animals they do not want, cannot sell, or are not allowed to keep. This is known as bycatch. In waters off Alaska, hook-and-line (sometimes called longline) fishing vessels use seabird avoidance measures that minimize seabird bycatch; no such measures are required for vessels fishing with trawl or pot gear. Despite these avoidance measures, seabirds are caught unintentionally as bycatch in certain commercial fisheries off Alaska. NOAA's National Marine Fisheries Service (NOAA Fisheries) is responsible for managing coastal and marine habitats through statutory authorities and agency policies. Additionally, NOAA Fisheries views seabirds as important ecosystem indicators and monitors seabird bycatch in many Federal fisheries for changes of interest to scientists and managers. Seabird populations can indicate the state of marine and coastal ecosystems. Changes in seabird bycatch could reveal long-term ecosystem effects or changes in coastal and marine habitats that seabirds depend on for various life stages. A summary of seabird bycatch and mitigation efforts in Alaska fisheries will be presented. This reviews seabird bycatch in commercial groundfish and halibut fisheries in the

exclusive economic zone off Alaska from 2007 through 2017.

#### AT-SEA ENERGETICS OF CAMPBELL AND GREY-HEADED ALBATROSSES IN RELATION TO SOUTHERN OCEAN WIND VARIABILITY

Caitlin E. Kroeger (ckroeger@ucsc.edu)<sup>1\*</sup>, Daniel E. Crocker (crocker@sonoma.edu)<sup>2</sup>, David R. Thompson (David.Thompson@niwa.co.nz)<sup>3</sup>, Leigh G. Torres (leigh.torres@oregonstate.edu)<sup>4</sup>, Paul M. Sagar (paul.joy.nz@gmail.com)<sup>5</sup>, Rachael A. Orben (rachael.orben@oregonstate.edu)<sup>1</sup>, and Scott A. Shaffer (scott.shaffer@sjsu.edu)<sup>6</sup>

<sup>1</sup>Department of Ocean Sciences, 1156 High St., University of California at Santa Cruz, Santa Cruz, CA USA 95064

<sup>2</sup>Department of Biology, Sonoma State University, 1801 E Cotati Ave, Rohnert Park, CA USA 94928

<sup>3</sup>National Institute of Water and Atmospheric Research Ltd (NIWA), 301 Evans Bay Parade, Hataitai, Wellington 6021, New Zealand

<sup>4</sup>Department of Fisheries and Wildlife, Marine Mammal Institute, Oregon State University, 2030 SE Marine Science Dr., Newport, OR USA 97365

<sup>5</sup>National Institute of Water & Atmospheric Research Ltd (NIWA), 10 Kyle St, Riccarton, Christchurch 8011, New Zealand

<sup>6</sup>Department of Biological Sciences, San Jose State University, One Washington Square, San Jose, CA USA 95192

Understanding environmental and behavioral factors that influence how organisms maintain energy balance can inform us about their potential resiliency to rapid environmental changes. This is particularly relevant to long-lived, central-place foraging seabirds that are constrained when locating food for offspring in a dynamic ocean environment while facing variable environmental conditions. We used doubly-labelled water to measure the at-sea daily energy expenditure of two sympatrically breeding seabirds, Campbell (*Thalassarche impavida*) and grey-headed (*T. chrysostoma*) albatrosses, during early chick-rearing in two consecutive seasons to understand the role of environmental interactions, behavioral flexibility, and morphological constraints on energy balance. We found that grey-headed albatrosses had greater foraging costs and that year was an important predictor of daily energy expenditure. Greater daily energy expenditure was also predicted by larger proportions of flight in slack winds ( $< 5 \text{ ms}^{-1}$ ), strong

headwinds ( $> 12 \text{ ms}^{-1}$ ), more daily water take-offs, greater post-trip body condition, and younger chick age. Additionally, daily energy expenditure was non-linearly correlated with low sea surface temperatures ( $< 4^\circ \text{C}$ ) and the relationship varied with sex. We suggest that differences in wing loading between species and sexes also influence these relationships. Poleward winds are forecasted to intensify over the next century, which may decrease daily energy expenditure for grey-headed albatrosses that heavily utilize this region during early-chick rearing. Female Campbell albatrosses that do not utilize poleward regions, may be negatively impacted by forecasted slackening winds in more northern regions that could force the use of less energy efficient sit-and-wait foraging strategies.

#### SEABIRD DISTRIBUTION RELATIVE TO BIOPHYSICAL OCEANOGRAPHIC PROPERTIES IN NORTH PACIFIC ECOSYSTEMS

Kathy Kuletz (Kathy\_Kuletz@fws.gov)<sup>1\*</sup>, Brian Hoover (bhoover@faralloninstitute.org)<sup>2</sup>, Daniel Cushing (dan.cushing@polestarecological.com)<sup>3</sup>, Jarrod Santora (jsantora@ucsc.edu)<sup>4</sup>, William Sydeman (wsydeman@comcast.net)<sup>5</sup>, Russell Hopcroft (rrhopcroft@alaska.edu)<sup>5</sup>, Seth Danielson (sldanielson@alaska.edu)<sup>5</sup>, Elizabeth Labunski (Elizabeth\_Labunski@fws.gov)<sup>1</sup>

<sup>1</sup>U.S. Fish and Wildlife Service, 1011 E. Tudor Rd., Anchorage, AK, USA, 99503

<sup>2</sup>Farallon Institute, 101 H. St., Petaluma CA, USA, 94952

<sup>3</sup>Pole Star Ecological Research LLC, Anchorage, AK, USA, 99501

<sup>4</sup>University of California, Santa Cruz, CA, USA, 95060

<sup>5</sup>College of Fisheries and Ocean Sciences, University of Alaska, Fairbanks, AK, USA, 99775

Seabirds are indicators of mesoscale changes in oceanographic properties and prey. Among the 28 Long-Term Ecological Research (LTER) sites within the National Science Foundation LTER system, two encompass marine ecosystems that allow us to examine broad-scale seabird distribution and species composition with respect to changes in the eastern Pacific Ocean. The Northern Gulf of Alaska LTER (NGA) started in April 2018, with the main study area monitored since 1998 (21 years) via other programs. The California Current Ecosystem LTER (CCE) has been monitored via multiple programs since 1987 (32 years). In the NGA, seasonal and long-term shifts in

cross-shelf seabird distribution have varied among seabird species, with ‘inshore’ species showing greater temporal and spatial changes. The same seabird species or ecological equivalents occur in the CCE, where changes in species abundance, richness, and community composition have been shown to be related to long-term changes in forage fish availability and climate change. The two LTERS vary in species richness (CCE is higher), intensity of seasonal variation (NGA is greater) and species composition, but they are linked by large-scale processes and impacts from climate change. Preliminary examination of density anomalies suggest that, for some species, birds in both LTERs co-vary in the same direction during ‘colder’ years, but in opposite directions during generally ‘warmer’ years. By comparing seabird-oceanographic relationships between these two large offshore marine ecosystems, we intend to inform predictions about the impact of rising ocean temperatures on upper trophic levels.

#### SPATIALLY-EXPLICIT NETWORK ANALYSIS REVEALS MULTI-SPECIES ANNUAL-CYCLE MOVEMENT PATTERNS OF SEA DUCKS

Juliet S. Lamb (jslamb@uri.edu)\*, Peter W.C. Paton<sup>1</sup>, Jason E. Osenkowski<sup>2</sup>, Shannon S. Badzinski<sup>3</sup>, Alicia M. Berlin<sup>4</sup>, Tim Bowman<sup>5</sup>, Chris Dwyer<sup>6</sup>, Luke J. Fara<sup>7</sup>, Scott G. Gilliland<sup>8</sup>, Kevin Kenow<sup>9</sup>, Christine Lepage<sup>10</sup>, Mark L. Mallory<sup>11</sup>, Glenn H. Olsen<sup>12</sup>, Matthew C. Perry<sup>13</sup>, Scott A. Petrie<sup>14</sup>, Jean-Pierre L. Savard<sup>15</sup>, Lucas Savoy<sup>16</sup>, Michael Schummer<sup>17</sup>, Caleb S. Spiegel<sup>18</sup>, and Scott R. McWilliams<sup>19</sup>

<sup>1</sup>Department of Natural Resources Science, University of Rhode Island, Kingston, RI, USA

<sup>2</sup>Rhode Island Department of Environmental Management, Kingston, RI, USA

<sup>3</sup>Canadian Wildlife Service, Ottawa, ON, Canada

<sup>4</sup>USGS Patuxent Wildlife Research Center, Laurel, MD, USA

<sup>5</sup>Sea Duck Joint Venture, US Fish and Wildlife Service, Anchorage, AK, USA

<sup>6</sup>U.S. Fish and Wildlife Service, Migratory Birds Division, Hadley, MA, USA

<sup>7</sup>U.S. Geological Survey, Upper Midwest Environmental Sciences Center, La Crosse, WI, USA

<sup>8</sup>Cooperative Wildlife Research Laboratory, Department of Zoology, Southern Illinois University, Carbondale, IL, USA

<sup>9</sup>Canadian Wildlife Service, Sackville, NB, Canada

<sup>10</sup>Canadian Wildlife Service, Québec City, QC, Canada

<sup>11</sup>Department of Biology, Acadia University, Wolfville, NS, Canada

<sup>12</sup>Delta Waterfowl, Bismarck, ND, USA

<sup>13</sup>Sciences and Technology, Environment Canada, Sainte-Foy, QC, Canada

<sup>14</sup>Biodiversity Research Institute, Portland, ME, USA

<sup>15</sup>Department of Environmental and Forest Biology, State University of NY College of Environmental Science and Forestry, Syracuse, NY, USA

Conservation of long-distance migratory species poses unique challenges. Migratory connectivity—that is, the extent to which groupings of individuals at breeding sites are maintained in wintering areas—is frequently used to evaluate population structure and assess use of key habitat areas. However, for species with complex or variable annual-cycle movements, this traditional bimodal framework of migratory connectivity may be overly simplistic. Like many other waterfowl, sea ducks often travel to specific pre- and post-breeding sites outside their nesting and wintering areas to prepare for migration and, in some cases, molt their flight feathers. These additional molt migrations may play a key role in population structure, but are not included in traditional models of migratory connectivity. Network analysis, which applies graph theory to assess landscape connectivity, offers a powerful tool for quantitatively assessing the contributions of different sites used throughout the annual cycle to complex spatial networks. We collected satellite telemetry data on annual cycle movements of over 500 individual sea ducks of five species from throughout eastern North America and the Great Lakes. From these data, we constructed a multi-species network model of migratory patterns and site use over the course of the breeding, molting, wintering, and migration periods. Our results highlight inter- and intra-specific differences in the patterns and complexity of annual-cycle movement patterns, including the central importance of staging and molting sites in James Bay and the St. Lawrence River to multi-species habitat connectivity. We also discuss potential applications of network migration models to conservation prioritization, identification of population units, and integrating different data streams.

#### JOINING THE AIRSPACE ABOVE SEABIRD COLONIES – DRONE AERIAL PHOTOGRAPHY IN COASTAL OREGON

Timothy J. Lawes

(Timothy.Lawes@oregonstate.edu)\*, Daniel D. Roby (Daniel.Roby@oregonstate.edu), James Tennyson (James@realtimeresearch.com)<sup>1</sup>, Aaron Turecek

(Aaron@realtimeresearch.com)<sup>2</sup>, and Donald E. Lyons (Dlyons@audubon.org)<sup>3</sup>

<sup>1</sup>Oregon Cooperative Fish and Wildlife Research Unit, Department of Fisheries & Wildlife, Oregon State University, 104 Nash Hall, Corvallis, OR 97331-3803 USA

<sup>2</sup>Real Time Research, Inc., 1000 SW Emkay Drive, Bend, OR 97702 USA

<sup>3</sup>National Audubon Society Seabird Restoration Program and Department of Fisheries and Wildlife, Oregon State University, 104 Nash Hall, Corvallis, OR 97331-3803 USA

The ubiquitous availability of unmanned aerial vehicles (UAVs), along with rule changes at the FAA that better codify UAV access to airspace, have increased opportunities to obtain high resolution aerial imagery of seabird colonies without the use of manned aircraft. In 2018, we used UAVs to take aerial imagery of a Caspian Tern (*Hydroprogne caspia*) colony and a Western Gull (*Larus occidentalis*) colony in coastal Oregon while monitoring for disturbance effects or aggressive responses to UAV over-flights. In addition, we compared resulting image quality from manned and UAV photographic flights of the tern colony, and evaluated the relative performance of low-end and mid-range UAV models produced by the same manufacturer. We found that Caspian Terns and Western Gulls tolerated UAVs overhead and did not initiate anti-predator responses at our study sites. Compared to the manned flights, orthomosaics of the tern colony generated using UAV imagery provided higher contrast imagery that was easier to count in a GIS environment, and UAVs allowed for the creation of additional imagery products such as 3D and Digital Elevation Models. Orthomosaics created from UAV imagery can, however, contain photo artifacts created by moving subjects (i.e. “ghost birds”), if not properly addressed and corrected during image processing. We found that coastal weather challenged flight performance of small UAVs, and the higher-end UAV generated better orthomosaic imagery. Although not a substitute for exploratory flights to locate seabird colonies, UAVs appear to be an excellent alternative for photographing surface nesting breeding colonies of tolerant species, while reducing the risk of human injury associated with manned survey flights.

## TWENTY YEARS OF BANDING WEDGE-TAILED SHEARWATERS (*ARDENA PACIFICA*, ‘UA’U KANI) IN MAUI NUI

Jennifer Learned ([learnedj@hawaii.edu](mailto:learnedj@hawaii.edu))<sup>1\*</sup>, Fern Duvall ([fern.p.duvall@hawaii.gov](mailto:fern.p.duvall@hawaii.gov))<sup>2</sup>, Jay Penniman ([jayfp@hawaii.edu](mailto:jayfp@hawaii.edu))

<sup>1</sup>Maui Nui Seabird Recovery Project, P.O. Box 903, Makawao, Hawai‘i 96768

<sup>2</sup>Hawaii Division of Forestry & Wildlife, 1955 Main Street, #301, Wailuku, Hawai‘i 96793

‘Ua’u kani (*Ardenna pacifica*, Wedge-tailed shearwater) breeding colonies persist across Maui Nui despite unremitting pressure from anthropogenic development, introduced predators, and sea level rise. Over the past decade, colonies benefiting from active predator control (Mo’omomi, Hawea) have been expanding, while others remain static or decline with predation (Ho’okipa, Kama’ole). Colonies on offshore islets (Molokini) are free of pressures from introduced predators and habitat loss, and likely serve as source populations as burrow space is limiting. Maui Nui Seabird Recovery Project leads chick banding and adult recapture efforts annually at five sites. Altogether, banding data from seven colonies and from intermittently recovered fallout birds create a 20-year record of ‘ua’u kani movement patterns.

Data indicate the majority of recaptured birds return to their home colony; however, emigration does occur, primarily from Molokini. Recapture rates increase at all sites, most significantly at Hawea and Mo’omomi, where predator control supports colony expansion. Recapture data also support the fallout bird recovery effort, revealing several cases of breeding birds returning 3-5 years after being grounded as juveniles. The ongoing ‘ua’u kani banding project is significant in many ways. Mark-recapture data reveal demographic and movement patterns, and show how management at the colony level can impact the larger population. In addition, it brings together partnership agencies and volunteers from the community, allowing for outreach and education about the native ecosystem, and for participation in conservation. These efforts are critical as ‘ua’u kani and other native species adapt within a rapidly changing environment.



## MODELING AT-SEA DISTRIBUTIONS OF MARINE BIRDS ON THE U.S. PACIFIC OUTER CONTINENTAL SHELF

Jeffery Leirness (jeffery.leirness@noaa.gov)<sup>1,2,\*</sup>, Brian Kinlan<sup>1</sup>, Josh Adams (josh\_adams@usgs.gov)<sup>3</sup>, Lisa Ballance (lisa.ballance@noaa.gov)<sup>1</sup>, Jonathan Felis (jfelis@usgs.gov)<sup>1</sup>, Trevor Joyce (trevorwjyoc@gmail.com)<sup>1</sup>, David Pereksta (david.pereksta@boem.gov)<sup>5</sup>, Michael Coyne (michael.coyne@noaa.gov)<sup>1,2</sup>, Arliss Winship (arliss.winship@noaa.gov)<sup>1,2</sup>

<sup>1</sup>US Department of Commerce, National Oceanic and Atmospheric Administration, National Ocean Service, National Centers for Coastal Ocean Science, Marine Spatial Ecology Division

<sup>2</sup>CSS, Inc.

<sup>3</sup>US Department of the Interior, US Geological Survey, Western Ecological Research Center, Santa Cruz Field Station

<sup>4</sup>US Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southwest Fisheries Science Center, Marine Mammal & Turtle Division

<sup>5</sup>US Department of the Interior, Bureau of Ocean Energy Management, Pacific Outer Continental Shelf Region

We report on the first phase of a multi-year effort to characterize the at-sea spatial distributions of marine birds on the US Pacific outer continental shelf (OCS). Results of this study will inform spatial planning and risk assessment for marine renewable energy in the region. We developed seasonal habitat-based spatial models of the at-sea distribution for 41 species of marine birds throughout the US Pacific OCS. A statistical modeling framework was used to estimate relationships between bird sighting data and a range of temporal and spatial environmental variables. The estimated relationships were then used to predict the long-term spatial distribution of each species throughout the study area in each season. Bird sighting data came from five scientific survey programs and consisted of at-sea counts of birds collected between 1996 and 2014 using fixed-wing aerial and boat-based transect survey methods. Environmental variables included temporal climate indices such as the Pacific Decadal Oscillation index, bathymetric variables such as depth and slope, and dynamic oceanographic and atmospheric variables such as chlorophyll concentration, surface current velocities, sea surface temperature, wind stress, and others. We present results for example species and discuss how the information can be interpreted to help guide marine

spatial planning and minimize potential conflict between human activities such as renewable energy development and seabirds. A second phase of the project is currently underway that includes contributed data from additional survey programs in an effort to expand and improve the modeling and results presented here.

## PELAGIC CORMORANT REPRODUCTIVE STATUS – 2018 SEASON.

Ron LeValley (ron@levalleyphoto.com)\*

P.O. Box 332, Little River CA 95456

Pelagic Cormorants (*Phalacrocorax pelagicus*) breed in small and scattered locations along the coast of North America from Alaska to Southern California. A citizen science project has been monitoring selected colonies in Northern California for ten years and has documented dramatic annual and spatial variation in breeding success. Some colonies have been occupied every year and others have been occupied sporadically. Estimating the long term population status of this species will require a long effort and a broad geographic scope. Here we present the results of the past ten years and document the very bad season that occurred in 2018. In 2018 we monitored many nests along the Mendocino and Sonoma County coast. Few of them hatched chicks and few chicks fledged. It was likely because there was no food in the ocean this spring and summer.

## CONSTRUCTING THE COMPLETE PROCELLARIIFORM TREE OF LIFE USING GENOME-SCALE DATA

Max Levy (max.levy@durham.ac.uk)\*, Andrea Estandia (and.estandia@gmail.com)<sup>1</sup>, Terry Chesser (chessert@si.edu)<sup>2</sup>, Helen James (jamesh@si.edu)<sup>3</sup>, Vincent Bretagnolle (breta@cebc.cnrs.fr)<sup>4</sup>, Andreanna Welch (a.j.welch@durham.ac.uk)<sup>1</sup>

<sup>1</sup>Department of Biosciences, Durham University, South Road, Durham, DH1 3LE, UK

<sup>2</sup>USGS Patuxent Wildlife Research Center, National Museum of Natural History, Smithsonian Institution, MRC 111, Washington, DC 20013-7012, USA

<sup>3</sup>Department of Vertebrate Zoology, National Museum of Natural History, Smithsonian Institution, MRC 116, Washington, DC 20013-7012, USA

<sup>4</sup>Equipe AGRIPPO, CEBC-CNRS, 79360, Beauvoir-sur-Niort, France

The seabird order Procellariiformes presents many taxonomic uncertainties, which has served to hinder the conservation of a group that is amongst the most threatened of all bird clades. Previous attempts to reconstruct Procellariiform phylogeny have been characterized by incomplete taxon sampling and reliance on single mitochondrial markers, namely cytochrome *b*. These works have been unable to fully elucidate the systematics and evolution of this taxonomically complex order both at broad and fine scales. Here I present preliminary results of work to produce a genome-scale phylogeny of all Procellariiform taxa. Using regions from across the avian genome we will create a species tree for almost all extant, and some recently extinct taxa of the order. This will provide high-resolution insights into ancient and recent divergences within the clade and answers to currently unresolved taxonomic questions. This dataset will also allow the mapping of ecological, morphological, and behavioral phenotypes onto the phylogeny to assess the evolution of these traits. Moreover, following a history of flux, approaching a standardized classification of Procellariiformes should enable better management and conservation of seabird populations in future.

#### TRIBAL-FEDERAL COLLABORATION ON EXPERIMENTAL HARVESTS OF GULL EGGS IN GLACIER BAY NATIONAL PARK

Tania Lewis (presenter; [tania\\_lewis@nps.gov](mailto:tania_lewis@nps.gov))\*, Darlene See ([darlene.see@hiatribe.org](mailto:darlene.see@hiatribe.org))<sup>2</sup> and Mary Beth Moss ([mary\\_beth\\_moss@nps.gov](mailto:mary_beth_moss@nps.gov))<sup>1</sup>

<sup>1</sup>Glacier Bay National Park and Preserve, P.O. Box 140, Gustavus AK 99826

<sup>2</sup>Hoonah Indian Association, 254 Roosevelt St. Hoonah AK 99829

In 2014, congressional legislation was passed to allow harvest of glaucous-winged gull (*Larus glaucescens*) eggs at up to 15 locations in Glacier Bay National Park by Hoonah Indian Association (HIA) tribal members. Since 2015, park biologists and HIA have collaborated on two experimental harvests to determine best-practices and potential impacts of a harvest. In 2015, we examined the effects of harvest on egg size in first clutches verses replacement clutches as decreasing egg size has been correlated with lower chick survival and may indicate limited food resources. We found no significant difference in egg size of harvested (n=97) verses replacement (n=20)

eggs. In 2017-2018, we conducted the second experimental egg harvest to determine whether egg quality, as determined by human consumption of harvested eggs, varies depending on the number of eggs present in a nest. In 2017 harvesters collected 75 eggs from 1 or 2-egg nests and 68 eggs from 3 egg nests. Survey results from egg recipients found that 13% of the eggs from 3-egg nests were considered inedible due to chick development compared to 3% from 1 and 2-egg nests. In 2018 harvesters collected 58 eggs from 1 or 2-egg nests and 69 eggs from 3 egg nests, of which all 127 eggs (100%) were edible. In both experiments the number of eggs laid in replacement clutches were lower than the number of eggs harvested at all locations. This information will help harvesters make decisions on nest selection to maximize edibility of eggs as well as inform future collaborative egg harvest plans by joining traditional ecological knowledge and practices with park research to ensure long-term stability of gull resources.

#### ASSOCIATIONS AMONG MASS MORTALITY EVENTS, SEABIRD DEMOGRAPHY, AND OCEAN CLIMATE TRENDS IN CENTRAL CALIFORNIA

Kirsten Lindquist([klindquist@farallones.org](mailto:klindquist@farallones.org))\*, Pete Warzybok([pwarzybok@pointblue.org](mailto:pwarzybok@pointblue.org))<sup>2</sup>, Nadav Nur([nnur@pointblue.org](mailto:nnur@pointblue.org))<sup>2</sup>, Jan Roletto([jan.roletto@noaa.gov](mailto:jan.roletto@noaa.gov))<sup>3</sup>, Taylor Nairn([Taylor.Nairn@noaa.gov](mailto:Taylor.Nairn@noaa.gov))<sup>3</sup>, and Jaime Jahncke([jjahncke@pointblue.org](mailto:jjahncke@pointblue.org))<sup>2</sup>

<sup>1</sup>Greater Farallones Association, 991 Marine Drive San Francisco, CA 94129

<sup>2</sup>Point Blue Conservation Science, 3820 Cypress Dr., #11, Petaluma, CA 94954

<sup>3</sup>Greater Farallones National Marine Sanctuary, ONMS, NOS, NOAA, 991 Marine Drive San Francisco, CA 94129

Over the past two decades there have been a growing number of Unusual Mortality Events (UME) along the U.S. West Coast and Alaska. In central California, seabird UMEs included Brandt's cormorants (*Phalacrocorax penicillatus*) in 2009, Cassin's auklets (*Ptychoramphus aleuticus*) in 2005 and 2014, and common murrelets (*Uria aalge*) in 2015. These resulted in large numbers of birds washing up on area beaches, causing concern among the public, and signaling ecosystem disruption. However, what drives these mortality events and how they impact local populations is unclear. To assess this, we integrated

long-term carcass deposition data from NOAA's Beach Watch Program with regional seabird population and productivity data as well as basin- and local-scale ocean climate indices to better understand beach survey data from an ecosystem perspective. We first used negative binomial regression to determine associations between carcass count, oceanographic variables, climate indices, prey availability, and seabird demography for each species of interest. We found significant relationships between increased carcass deposition and decreased or delayed upwelling and during periods of warm ocean temperatures associated with El Niño. Next, we used generalized linear models to examine the relationship between carcass deposition and subsequent changes in breeding population size. We found significant relationships between carcass density and magnitude of population change but the relationships varied among species and age classes examined. When ocean climate indices were added to the model, most estimates of mortality dropped out, indicating that the ocean climate variables explain seabird population trends better than carcass deposition.

#### THE "NEW NORMAL" OF SEABIRD MASS MORTALITY EVENTS

Jackie Lindsey (jackieklindsey@gmail.com)<sup>1\*</sup>, Tim Jones (timothy.t.jones@googlegmail.com)<sup>1\*\*</sup>, Hillary Burgess (hkb10@uw.edu)<sup>1</sup>, Julia K Parrish (jparrish@uw.edu)<sup>1</sup>, Stacia Backensto (stacia\_backensto@nps.gov)<sup>2</sup>, Victoria Bowes (Victoria.Bowes@gov.bc.ca)<sup>3</sup>, Lauren Divine (lmdivine@aleut.com)<sup>4</sup>, Jane E. Dolliver (jane.dolliver@oregonstate.edu)<sup>5</sup>, Corinne Gible (corinne.gible@wildlife.ca.gov)<sup>6</sup>, James T. Harvey (jharvey@mlml.calstate.edu)<sup>7</sup>, Peter Hodum (peter@oikonos.org)<sup>8</sup>, Robert Kaler (robert\_kaler@fws.gov)<sup>9</sup>, Kathy Kuletz (kathy\_kuletz@fws.gov)<sup>9</sup>, Aaron Lestenkof (aplestenkof@aleut.com)<sup>4</sup>, Pamela Lestenkof (pmlestenkof@aleut.com)<sup>4</sup>, Kirsten Lindquist (klindquist@farallones.org)<sup>10</sup>, Paul Melovidov (pimelovidov@aleut.com)<sup>4</sup>, Hannahrose M. Nevins (hnevins@abcbirds.org)<sup>11</sup>, Scott Pearson (Scott.Pearson@dfw.wa.gov)<sup>12</sup>, John Piatt (jpiatt@usgs.gov)<sup>13</sup>, Heather Renner (heather\_renner@fws.gov)<sup>14</sup>, Jan Roletto (jan.roletto@noaa.gov)<sup>10</sup>, Marc Romano (marc\_romano@fws.gov)<sup>14</sup>, Gay Sheffield (ggsheffield@alaska.edu)<sup>15</sup>, Sue Thomas (Sue\_Thomas@fws.gov)<sup>16</sup>, Laurie Wilson (laurie.wilson@canada.ca)<sup>17</sup>

<sup>1</sup>Coastal Observation and Seabird Survey Team (COASST), 1122 NE Boat St, Seattle, WA 98105

<sup>2</sup>NPS Arctic Network Inventory and Monitoring, 4175 Geist Rd, Fairbanks, AK 99709

<sup>3</sup>Animal Health Centre, Ministry of Agriculture, Abbotsford Agricultural Centre, Abbotsford, British Columbia, Canada

<sup>4</sup>Aleut Community of St. Paul Island Ecosystem Conservation Office, 2050 Venia Minor Road, Saint Paul Island 99660

<sup>5</sup>Department of Fisheries and Wildlife, Oregon State University, Corvallis, OR, USA

<sup>6</sup>California Department of Fish and Wildlife, 151 McAllister Way, Santa Cruz, CA 95060

<sup>7</sup>Coastal Ocean Mammal and Bird Education and Research Surveys (BeachCOMBERS), Moss Landing Marine Laboratories, California State University, Moss Landing, CA, USA

<sup>8</sup>University of Puget Sound, Tacoma, WA 98416

<sup>9</sup>USFWS, Migratory Bird Management, 1011 East Tudor Road, MS 201, Anchorage, Alaska 99503

<sup>10</sup>Farallones Marine Sanctuary Association, 991 Marine Drive, San Francisco, CA 94129 USA

<sup>11</sup>American Bird Conservancy, Santa Cruz, CA, USA

<sup>12</sup>Washington Department of Fish and Wildlife, 600 Capitol Wy N, Olympia, WA 98501

<sup>13</sup>USGS, 616 Marrowstone Pt Rd, Nordland, WA 98358

<sup>14</sup>Alaska Maritime National Wildlife Refuge, 95 Sterling Highway, Suite 1, Homer, Alaska 99603

<sup>15</sup>University of Alaska Fairbanks, Alaska Sea Grant, 400 East Front Street, Nome, AK 99762

<sup>16</sup>USFWS, Washington Maritime National Wildlife Refuge Complex, 715 Holgerson Rd, Sequim, WA 98382, USA

<sup>17</sup>Marine and Terrestrial Unit, Canadian Wildlife Service, Environment and Climate Change Canada, Delta, British Columbia, Canada

Recent research has highlighted that the frequency and magnitude of animal mass mortality events (MMEs) have increased over the last half a century, and that mortality events are likely to become more frequent with an increasingly variable climate. Since 2014 the North Pacific has experienced 7 seabird mass mortality events, starting with Cassin's Auklets (*Ptychoramphus aleuticus*) along the West Coast in 2014-15, through a suite of species - chiefly murres (*Uria*) and fulmars (*Fulmarus glacialis*) - in the Bering Strait region in 2018. In total, these events resulted in millions of mortalities. Although these regions have experienced MMEs in the past, the frequency, duration and magnitude of MMEs increased sharply following the onset of a series of warming forces, including the northeast Pacific marine heatwave, a weak El Niño, and continued Arctic warming (indicated by changes

in sea ice extent, the Bering Sea cold pool, and sea surface temperatures). Despite the general linkage between a warmer ocean and seabird MMEs, the operational relationship between elevated sea temperatures and the observed effects on seabirds is currently poorly understood. Causative factors are likely to be multifactorial, including but not limited to: (1) Shifting Prey Base; (2) Disease; (3) Harmful Algal Blooms; (4) Extreme Weather; and (5) Shifting Physical Cues (e.g. freeze-up and break-up). We used data from a citizen science survey program focused on beached birds (COASST), as well as information from coastal communities; state, federal and tribal agencies; and other beached bird programs to provide an overview of seabird mortality events affecting the North Pacific and northern Alaskan coastal regions over the last 16 years.

#### CHALLENGES AND LESSONS LEARNED IN ADDRESSING HUMAN HARVEST OF PINK-FOOTED SHEARWATERS ON ISLA MOCHA, CHILE.

Verónica López ([veronica@oikonos.org](mailto:veronica@oikonos.org))\*, Tiare Varela, Matías Portflitt-Toro ([matias.portflitt.t@gmail.com](mailto:matias.portflitt.t@gmail.com)), Cristián Cornejo ([ccornejo.8@mma.gob.cl](mailto:ccornejo.8@mma.gob.cl))<sup>3</sup>, Guillermo Reyes ([guillermo.reyes@conaf.cl](mailto:guillermo.reyes@conaf.cl))<sup>4</sup>, Manuel Contreras<sup>5</sup>.

<sup>1</sup>Oikonos Ecosystem Knowledge, Valparaíso, Chile.

<sup>2</sup>Millennium Nucleus Ecology and Sustainable Management of Oceanic Island (ESMOI). Universidad Católica del Norte.

<sup>3</sup>Ministerio de Medio Ambiente (MMA). Chile.

<sup>4</sup>Corporación Nacional Forestal (CONAF), Chile.

<sup>5</sup>Centro de Ecología Aplicada (CEA). Chile.

To demonstrate how extreme wildlife-human conflicts can generate new approaches to conservation, we present a case study of a seabird harvest event on Isla Mocha, Chile. Isla Mocha is home to approximately 70% of the world population of the globally threatened Pink-footed Shearwater (*Ardenna creatopus*) and to a community of 600 residents. Shearwater chicks were harvested annually by residents until the hunting was prohibited by Chilean law. Illegal hunting events of 20 to 40 individuals were recorded almost every year since the ban, but, in 2018, about 300 carcasses were found at one time. This event created a subsequent conflict in the island community and a conflagration via social media. Social media posts were seen by more than 400,000 people, shared 2600 times, and received 1700 comments, with 83% of more than 10,000 reactions strongly condemning the event. To demonstrate the importance of understanding

perceptions and needs of the different stakeholders involved, we present the positive and negative outcomes of the harvest, the prosecution, and approaches taken by the government and NGOs to resolve the conflict. One outcome was the development of multi-disciplinary strategies to reestablish trust, as some Mocha residents felt abandoned by Oikonos and the agencies who exposed the harvest. Another outcome was an increased commitment by government agencies to engage in solutions upon realizing the high level of national and international concern for this species. Environmental conflicts can create opportunities to adjust perspectives common, approaches, and improve relationships between stakeholders that are crucial for seabird conservation.

#### SEASONAL CHANGES IN TERN COLONY ATTENDANCE AND LOCATION AT A PREDATOR-RICH MAINLAND AREA IN SOUTHEAST ALASKA

Janelle Lopez ([janellewolf08@gmail.com](mailto:janellewolf08@gmail.com))\*, Donald E. Lyons ([don.lyons@oregonstate.edu](mailto:don.lyons@oregonstate.edu)), Susan Oehlers ([soehlers@fs.fed.us](mailto:soehlers@fs.fed.us))<sup>3</sup>

<sup>1</sup>Yakutat Ranger District, Ocean Cape Rd, Yakutat, AK 99689

<sup>2</sup>Tongass National Forest, Yakutat Ranger District, Ocean Cape Rd, Yakutat, AK 99689

<sup>3</sup>Oregon State University, 104 Nash Hall, Corvallis, OR 97331

For the past decade, the size and location of a mixed colony of Aleutian terns (*Onychoprion aleuticus*) and Arctic terns (*Sterna paradisea*) has been quite variable both during and across breeding seasons on Black Sand Spit, an approximate eight-mile barrier spit located near Yakutat, Alaska. This colony is the largest colony of Aleutian terns known to exist in Alaska, sometimes reaching several thousand individuals. To track colony size and location, modified direct count surveys have been conducted annually across areas with nesting terns. The modified survey consists of two observers conducting independent direct counts of adult terns and nests sighted within ~50m from the colony boundary during a 60 second time interval. Nesting has occurred across many locations on the spit, with the number of breeding pairs highly variable. A significant predator presence has been documented during the 2017 and 2018 breeding seasons using trail cameras deployed to monitor nest attendance and success. High nest depredation rates were observed throughout the colony and photos revealed common

ravens (*Corvus corax*), coyotes (*Canis latrans*), and bald eagles (*Haliaeetus leucocephalus*) predating on nests. Presumably, terns shift locations and/or abandon nesting efforts at high rates in response to this predation pressure, but they have not abandoned the site despite repeated nesting failures.

#### CLOSE COLONY MONITORING UNCOVERS NEW THREATS TO NESTING SUCCESS IN THE CRITICALLY ENDANGERED CHINESE CRESTED TERN

Yiwei Lu([luyw@zmnh.com](mailto:luyw@zmnh.com))\*, Dongdong Chen([503145631@qq.com](mailto:503145631@qq.com))<sup>2</sup>, Xiao Zhou([zxycy1991@126.com](mailto:zxycy1991@126.com))<sup>2</sup>, Zhongyong Fan([Fanzhy@zmnh.com](mailto:Fanzhy@zmnh.com))<sup>1</sup>, Daniel D. Roby([daniel.robby@oregonstate.edu](mailto:daniel.robby@oregonstate.edu))<sup>3</sup>, Donald E. Lyons([don.lyons@oregonstate.edu](mailto:don.lyons@oregonstate.edu))<sup>3</sup>, Siyu Wang([812355207@qq.com](mailto:812355207@qq.com))<sup>2</sup>, Jia Yang([yjyangling@163.com](mailto:yjyangling@163.com))<sup>1</sup>, and Shuihua Chen([chensh@zmnh.com](mailto:chensh@zmnh.com))\*

<sup>1</sup>Zhejiang Museum of Natural History, Hangzhou, China

<sup>2</sup>Zhejiang Normal University, Jinhua, China

<sup>3</sup>Oregon Cooperative Fish and Wildlife Research Unit, Department of Fisheries and Wildlife, Oregon State University, Corvallis, Oregon, USA

<sup>4</sup>National Audubon Society Seabird Restoration Program, Corvallis, Oregon, USA

The Chinese Crested Tern (*Thalasseus bernsteini*) is a critically endangered seabird breeding mainly in the East China Sea. Previous studies uncovered major threats to the species, including illegal egg harvest and typhoons. Since 2013 we have conducted a tern restoration project in the Jiushan Archipelago using social attraction techniques (decoys and audio playbacks) to establish a new breeding colony of Greater Crested Terns (*T. bergii*) and Chinese Crested Terns. Close monitoring allowed us to detect other potential threats to any new tern breeding colony at the restoration site. We used direct observation by resident colony monitors from blinds at the edge of the colony site, surveillance video cameras, and snake traps deployed next to the colony to investigate factors limiting the size and nesting success of the newly restored tern colony. We discovered that king rat snakes (*Elaphe carinata*) and Peregrine Falcons (*Falco peregrinus*) were two major predators at the new tern colony. The snake, a common species on coastal islands in East and Southeast Asia, ate tern eggs on the colony early in the 2016 nesting season until all adult terns abandoned the colony site. Peregrine Falcons

visited the colony site frequently during the breeding seasons of 2014, 2015 and 2017, and were documented depredating at least 5 Greater Crested Terns. Disturbances to the colony by hunting falcons also caused a significant increase in nest failures. Our results provide further insight to the threats and obstacles to restoration of the Chinese Crested Tern, and suggest that king rat snakes may be a major and previously overlooked threat to seabird nesting success at colonies on coastal islands in East and Southeast Asia.

#### QUANTIFYING THE PROSPECTING BEHAVIOR AND BREEDING NETWORKS OF TERNS NESTING IN EPHEMERAL HABITATS

Donald E. Lyons ([dlyons@audubon.org](mailto:dlyons@audubon.org))\*, Allison Patterson ([allisonglider@gmail.com](mailto:allisonglider@gmail.com))<sup>2</sup>, Timothy J. Lawes ([timothy.lawes@oregonstate.edu](mailto:timothy.lawes@oregonstate.edu))<sup>3</sup>, and Daniel D. Roby ([daniel.robby@oregonstate.edu](mailto:daniel.robby@oregonstate.edu))<sup>3</sup>

<sup>1</sup>National Audubon Society Seabird Restoration Program and Department of Fisheries and Wildlife, Oregon State University, 104 Nash Hall, Corvallis, OR 97331-3803 USA

<sup>2</sup>Department of Natural Resource Sciences, McGill University, Ste-Anne-de-Bellevue, Quebec H9X 3V9 Canada

<sup>3</sup>Oregon Cooperative Fish and Wildlife Research Unit, Department of Fisheries and Wildlife, Oregon State University, 104 Nash Hall, Corvallis, OR 97331-3803 USA

Ground-nesting waterbirds that breed colonially on islands in estuaries, wetlands, rivers, and lakes must be adapted to deal with high inter-annual variability in habitat availability. To quantify the degree of regional connectivity and prospecting behavior of Caspian Terns (*Hydroprogne caspia*), a coastal and continental tern species that nests in sparsely vegetated insular habitats, we used a combination of network and spatial analyses to evaluate a satellite tracking dataset from 64 Caspian Terns tagged at two colonies in central Washington State, USA. Tagged terns visited 21 known colonies from Alaska to southern California. Over the entire tracking period, each colony was visited by 26 terns on average. Twenty of the 21 colonies were directly linked to at least 10 other colonies. The average shortest path between pairs of sites was two sites; three colonies served as network centers connecting multiple colonies. Terns tracked for at least two breeding seasons visited an average of 10 colonies

overall, and each year individual terns visited more than 70% of all colonies in their personal network. Prospecting activity was more intense during the post-breeding period, with individual terns visiting seven colonies during post-breeding and five colonies during the pre-breeding period in the same year. The networks of individual terns occurred over large spatial extents; the area encompassing all sites visited each year averaged 235,000 km<sup>2</sup> per individual. Consistent with predictions based on their nesting habitat selection, colonies within the Pacific Coast region showed strong connectivity and Caspian Terns regularly sampled a significant proportion of all potential breeding colonies across their entire breeding range.

#### WHERE HAVE ALL THE BIRDS GONE?: CHANGES IN AT-SEA DENSITIES OF SEABIRDS IN KACHEMAK BAY, ALASKA FROM 1996 TO 2018

Caitlin Marsteller (cmarsteller@usgs.gov)<sup>1</sup>\*, Mayumi Arimitsu (marimitsu@usgs.gov)<sup>2</sup>, John Piatt (jpiatt@usgs.gov)<sup>3</sup>, Kathy Kuletz (kathy\_kuletz@fws.gov)<sup>3</sup>, Sarah Schoen (sschoen@usgs.gov)<sup>1</sup>, Brielle Heflin (bheflin@usgs.gov)<sup>2</sup>, and Elizabeth Labunski (Elizabeth\_Labunski@fws.gov)<sup>3</sup>

<sup>1</sup>USGS Alaska Science Center, 4210 University Drive, Anchorage, AK USA 99508

<sup>2</sup>USGS Alaska Science Center, 250 Egan Drive, Juneau, AK USA 99801

<sup>3</sup>U.S. Fish & Wildlife Service, 1011 E. Tudor Road, Anchorage, AK USA 99503

Seabirds are useful indicators of changing ocean conditions and prey resources in marine ecosystems. Accordingly, the status and trends of seabird populations in Kachemak Bay have been used to assess potential effects from events such as the 1989 *Exxon Valdez* oil spill and the 2014-2016 marine heat wave, both of which resulted in large mortalities of Common Murres (*Uria aalge*) in this region. To track long-term changes in various populations, at-sea surveys were used to document summer (May – August) distribution and abundance of seabirds in Kachemak Bay during 11 years between 1996 and 2018 (1996-1999, 2005-2007, 2011, and 2016-2018). The most abundant species over all years were shearwaters (*Ardenna* spp.), Marbled Murrelets (*Brachyramphus marmoratus*), Black-legged Kittiwakes (*Rissa tridactyla*), Common Murres, and Glaucous-winged Gulls (*Larus glaucescens*). Densities (# birds/km<sup>2</sup>) of

these species, and others, have fluctuated considerably throughout the two decades of study. However, 2018 was a particularly unusual year in that densities of both common and uncommon species declined dramatically, and the overall density of all species was the lowest ever recorded. In our recent studies, we also collected ancillary data on forage fish abundance and breeding success of murres and kittiwakes at local colonies. This combined data suggests a major perturbation of food webs in lower Cook Inlet following the 2014-2016 marine heat wave, with a persistent effect manifested in the extreme low densities of seabirds at sea in 2018.

#### NOVEL USE OF MINK FARMS AND CONTAMINANT BIOTRANSPORT BY GULLS IN SOUTHWESTERN NOVA SCOTIA, CANADA

Jessie McIntyre (jessiemcintyre@acadiau.ca)<sup>\*</sup>, Mark Mallory

<sup>\*</sup>Acadia University, 33 Westwood Avenue, Wolfville, Nova Scotia, Canada, B4P 2R6

Seabirds are effective biotransporters of contaminants, moving them from marine food chains to terrestrial environments around breeding colonies, and these processes can have marked impacts on the receiving environments and biota. As generalist predators, herring gulls (*Larus argentatus*) can exploit a wide range of natural and anthropogenic food items including exposed crops and waste at agricultural sites. Mink (*Mustela vison*) farming is an economically important agricultural industry in southwestern Nova Scotia, Canada which produces wastes in the form of carcasses and fishmeal, but the potential broad environmental impacts of this localized food source, including the spread of contaminated materials by gulls, have not been properly assessed. To track herring gulls, I deployed solar-powered GPS tags on gulls caught using drop traps at two breeding colonies. During the incubation and chick rearing period, gulls displayed specialized foraging patterns with some birds frequenting mink farms. This establishes that gulls are foraging at farms and are likely moving contaminated materials from farms to distant coastal colonies (>50 km) broadening the spatial environmental impacts of mink farming in the region. Surface and soil cores were collected from colonies and nearby gull-free reference sites to compare trace elements and persistent organic pollutants deposited by gulls. This work, along with collaborative limnological and paleolimnological work on receiving

watersheds below the mink farms, will help measure impacts of this industry to inform government and industry of the scale of impacts of such anthropogenic activities that produce abundant foods for generalist predators.

#### ACOUSTIC SURVEYS OF STORM-PETRELS IN THE CALIFORNIA COASTAL NATIONAL MONUMENT: DETECTION AND QUANTIFICATION OF VOCAL ACTIVITY

Matthew McKown (matthew@conservationmetrics.com)<sup>1</sup>\*, Jonathan Felis<sup>2</sup>, Emma Kelsey<sup>2</sup>, Kerry Dunleavy<sup>1</sup>, and Josh Adams<sup>2</sup>

<sup>1</sup> Conservation Metrics, 145 McAllister Way, Santa Cruz, CA 95060 USA

<sup>2</sup>US Geological Survey, Western Ecological Research Center, Santa Cruz Field Station, 2885 Mission Street, Santa Cruz, CA 95060 USA

Passive acoustic surveys can be useful for documenting the distribution of rare and elusive seabirds at sites that are difficult to access. Here we present results from a large-scale passive acoustic survey to document Ashy Storm-petrel (*Oceanodroma homochroa*), Leach's Storm-petrel (*O. leucorhoa*), Fork-tailed Storm-petrel (*O. furcata*), and Black Storm-petrel (*O. melania*) at potential breeding sites throughout California. Specifically, we are evaluating the cost-effectiveness of acoustic surveys for monitoring storm-petrels in the California Coastal National Monument (CCNM; includes over 20,000 rocks, stacks, and islands stretching for 1,100 miles from San Diego to Oregon). We deployed 23 sensors at sites inside and outside the CCNM between March 1 and October 24, 2017. We detected Ashy Storm-petrel calls (15 of 23 survey sites), Leach's Storm-petrel calls (5 of the 23 survey sites), Black Storm-petrel calls (2 of 10 sites analyzed, both on Santa Barbara Island). Fork-tailed Storm-petrel calls were only detected north of Cape Mendocino at Castle Rock North (Del Norte Co.) and Little River Rock (Humboldt Co.). We repeated surveys in 2018, and present preliminary data for this year. We compared our results with acoustic data from other known storm-petrel breeding colonies outside the Monument and with published observational data from previous surveys conducted by Harry Carter (and colleagues). Finally, we discuss additional research to improve interpretation of acoustic activity rates by comparing activity to mist-net capture rates, and the address feasibility of

creating a range-wide, long-term survey network for monitoring these elusive species.

#### LESSONS FROM SEABIRD CONSERVATION IN ALASKA LONGLINE FISHERIES

Edward F. Melvin (edmelvin@uw.edu)<sup>1</sup>\*, Kimberly S. Dietrich (kim@kimdietrich.com)<sup>2</sup>, Robert M. Suryan (rob.suryan@noaa.gov)<sup>3</sup>, and Shannon M. Fitzgerald (Shannon.Fitzgerald@noaa.gov)<sup>4</sup>

<sup>1</sup>Washington Sea Grant, 3716 Brooklyn Ave NE, Seattle, WA 98105 USA

<sup>2</sup>5091 Starfish Drive SE, St. Petersburg, FL 33705 USA

<sup>3</sup>NOAA Fisheries, Alaska Fisheries Science Center, Auke Bay Laboratories, Ted Steven's Marine Research Institute, 17109 Pt. Lena Loop Rd., Juneau, Alaska, 99801, USA

<sup>4</sup>Resource Ecology and Fisheries Management Division, Alaska Fisheries Science Center, National Marine Fisheries Service, NOAA, 7600 Sand Point Way NE, Seattle WA 98115

Although the incidental mortality (bycatch) of seabirds and other long-lived species ranks among the most critical conservation issues in world fisheries, case studies documenting significant reductions in the mortality of these low productivity species in a fishery are rare. We present a case history of seabird conservation in one of the largest and most diverse demersal longline fisheries in the world, Alaska longline fisheries. Our analysis of 23 years of fisheries observer data spans pre and post adoption of streamer lines – a seabird bycatch prevention measure developed in an intensive collaborative research program with industry. Following adoption of streamer lines, at first voluntarily and then by regulation, seabird bycatch per unit effort (BPUE) was reduced by 77% to 90% preventing the mortality of thousands of birds per year. Despite this clear success, our models also showed significant increasing trends in the BPUE in two of four target fisheries since streamer lines were adopted. Our finding that a small number of vessels accounted for a disproportionate number of seabird captures in the observed bycatch may partially explain these trends. Although night setting yielded significant reductions (74% to 97%) in seabird BPUE and significant increases (7% to 11%) in target fish catch per unit effort compared to daytime setting, nighttime setting increased the BPUE of northern fulmar (*Fulmarus glacialis*) by 40%. Our findings suggest that best practices to prevent seabird mortalities in longline fisheries vary by seabird species

assemblage and fishery. This case study informs global fisheries bycatch reduction efforts by illustrating that successful conservation requires: fishery specific solutions, strong industry support, constant vigilance in analysis and reporting of observer data, as well as ongoing outreach to fleets, especially to those vessels with anomalously high BPUE.

#### DISTRIBUTION AND ABUNDANCE OF MARINE BIRDS IN AN INDUSTRIALIZED SEA: VESSEL-BASED SURVEYS IN THE GULF OF MEXICO

Pamela E. Michael (pemicha@g.clemson.edu)\*, Jeffery S. Gleason (jeffrey\_gleason@fws.gov)†, J. Chris. Haney (jchrishaney@terramarappliedsciences.com)‡, Y. Satgé (ysatge@g.clemson.edu)§, Patrick G. R. Jodice (pjodice@g.clemson.edu)¶

\*South Carolina Cooperative Fish and Wildlife Research Unit, Department of Forestry and Environmental Conservation, 238 Lehotsky Hall, Clemson University, Clemson, SC USA 29634

†U.S. Fish and Wildlife Service, Gulf Restoration Office, 16450 NW 31 Place, Chiefland, FL USA 32626

‡Terra Mar Applied Sciences LLC, 1304 Rittenhouse Street, NW, Washington, DC USA 20011

§U.S. Geological Survey South Carolina Cooperative Fish and Wildlife Research Unit, Clemson University, 238 Lehotsky Hall, Clemson, SC USA 29634

Seabird surveys associated with the Gulf of Mexico Marine Assessment Program for Protected Species (GoMMAPPS) are uncovering previously unknown aspects of the distribution, abundance, and seasonality for these apex predators. From April 2017 - October 2018 we have conducted ~ 165 days of surveys on 13 NOAA cruises. Using standard, transect-based methodology we have amassed ~ 5,700 detections of 36 seabird species totaling ~ 25k seabirds. Preliminary results suggest a significant number of the continent's black terns (*Chlidonias niger*) use the Mississippi River delta as staging, migratory, and nonbreeding habitat for up to eight months of the year. Although commonly associated with tropical coastal environments, we have observed the brown booby (*Sula leucogaster*) to be widespread in pelagic Gulf waters, even more so than the regionally-breeding masked booby (*Sula dactylatra*). Seasonal use of the Gulf by Macaronesian-breeding band-rumped storm-petrels (*Oceanodroma castro*) span at least March to September, more than two months longer than recorded for this species elsewhere off the

southeastern United States. Finally, we are regularly detecting black-capped petrel (*Pterodroma hasitata*) using the offshore Gulf, a finding most notable for the fact that this threatened species is currently petitioned for protection under the Endangered Species Act. These novel insights into the habitat use and distributions of the seabirds using the Gulf of Mexico provide an important ecological context for current regional activities and can inform the development of future activities.

#### ENVIRONMENTAL VARIANCE AND DIET-DEPENDENT SEXUAL ORNAMENTS IN BROWN BOOBY POPULATIONS

Nathan Michael (Npm19@uakron.edu)†, Anne Wiley (awiley@uakron.edu)†, Roxanna Torres‡, Andreanna J. Welch‡, Mario Erandi Bonillas-Monge‡, Samantha Hodgson‡, Laura Lopez-Marquez‡, Alejandro Martínez-Flores‡, Jonathan Felis‡, Josh Adams‡

†University of Akron, 302 Buchtel Ave, Akron, OH USA 44325

‡Universidad Nacional Autónoma de México, Instituto de Ecología, México City, México

§Durham University, Durham DH1, UK

¶United States Geological Survey, Western Ecology Research Center, 2885 Mission St, Santa Cruz, CA USA 95060

We often assume conspecifics experience similar limitations when generating sexual ornaments. However, populations of seabirds in close proximity may experience different environments that lead to distinct foraging behaviors, which may influence production and selection of diet-linked carotenoid ornaments. We studied the relationship between diet and carotenoid-based skin ornaments in three populations of Brown Booby (*Sula leucogaster*) along an environmental gradient on the west Mexican coast. We combined stable isotope analysis of blood plasma with GPS tracking data from males nesting at Isla San Jorge & Isla San Pedro Mártir the high-productivity Gulf of California, and from Islas Marietas located in a lower-productivity, oceanic area. Marietas boobies showed a strong negative relationship between gular skin color (green chroma) and  $\delta^{13}\text{C}$ , with greener, presumably more attractive ornaments corresponding with lower carbon isotope values. GPS tracking results corroborated that lower  $\delta^{13}\text{C}$  values were indicative of more offshore foraging. In contrast, San Jorge birds showed no relationship between gular color and  $\delta^{13}\text{C}$ , but a revealed a positive relationship between foot green chroma and  $\delta^{13}\text{C}$ . Whereas these results indicate



that pelagic prey influence formation of carotenoid-rich ornaments in *Marietas*, the reverse is true for birds within the shallow waters of the northern Gulf of California. Furthermore, foot skin color appears to be a reliable indicator of diet on the rocky island of San Jorge, whereas gular skin color is clearly linked to diet on the grass-covered islands of *Marietas*. Our study demonstrates the importance of considering environmental variance in the study of taxonomically-widespread carotenoid-ornaments.

#### HOW DO SEABIRDS PERCEIVE LIGHT? SPECTRAL EFFECTS ON THE TEMPORAL SENSITIVITY OF HAWAIIAN SEABIRDS

Hannah Moon ([hmoon@hawaii.edu](mailto:hmoon@hawaii.edu))\*, Tracy Anderson ([tracy@kauaihumane.org](mailto:tracy@kauaihumane.org)), Marc Travers ([marc.s.travers@gmail.com](mailto:marc.s.travers@gmail.com)), Ellis Loew ([erl1@cornell.edu](mailto:erl1@cornell.edu))<sup>4</sup>, Megan Porter ([mlporter@hawaii.edu](mailto:mlporter@hawaii.edu))<sup>1</sup>

<sup>1</sup>Department of Biology, 2538 McCarthy Mall, EDM 216, University of Hawai'i at Mānoa, Honolulu, HI 96822

<sup>2</sup>Save Our Shearwaters, Kauai Humane Society, P.O. Box 3330 Lihue, HI 96766

<sup>3</sup>Kauai Endangered Seabird Recovery Project, 3900 Hanapepe Rd, Hanapepe, Kaua'i 96716

<sup>4</sup>Department of Biomedical Sciences, Cornell University, Ithaca, NY 14853

Artificial lights at night cause high mortality in fledgling seabirds due to attraction and subsequent grounding. The seabirds most affected by grounding are Procellariiformes, including shearwaters and petrels. Of concern on Kaua'i are the Hawaiian Petrel (*Pterodroma sandwichensis*), Newell's shearwater (*Puffinus newelli*), and the Wedge-tailed shearwater (*Ardenna pacifica*). Newell's Shearwater fledglings have the highest susceptibility, which suggests differences in behavior and/or vision between species as well as between fledglings and adults. Previous studies on migratory birds suggest that the color of light can affect attraction. To better understand visual perception in seabirds and drivers of fatal light attraction, the temporal sensitivity of the target species was tested in different spectra and intensities of light. Flashing LED lights were used in up to five intensities in three wavelengths- violet (385nm), blue (450nm), and white light (peak at 594nm). Electoretinography was used to measure the magnitude of response in the eye to each intensity and identify the flicker fusion frequency. Juveniles of all

three species and one adult *A. pacifica* have been tested by the end of the first field season. All species were sensitive to 385nm light at bright intensities, suggesting a violet sensitive visual system. Preliminary analyses suggest a flicker fusion frequency of about 30Hz in the violet-sensitive photoreceptor of *P. newelli*. Preliminary results also suggest variation in response of the eye to different colors of light between species and life stages. Ultimately, a greater understanding of the physiology of visual systems in seabirds may help us reduce artificial light attraction and groundings in the future.

#### DECADAL AND MILLENNIAL-SCALE FORAGING HABITS OF THREE HAWAIIAN SEABIRDS: AMINO ACID $\delta^{15}\text{N}$ , $\delta^{13}\text{C}$ , AND $\delta\text{D}$ ANALYSES

Kaycee Morra ([kayceem@ucr.edu](mailto:kayceem@ucr.edu))\*, Marilyn Fogel ([marilyn.fogel@ucr.edu](mailto:marilyn.fogel@ucr.edu))<sup>1</sup>, Peggy Ostrom ([ostrom@msu.edu](mailto:ostrom@msu.edu))<sup>2</sup>, Anne Wiley ([awiley@uakron.edu](mailto:awiley@uakron.edu))<sup>3</sup>, Yoshito Chikaraishi ([riki\\_riki@me.com](mailto:riki_riki@me.com))<sup>4</sup>, Helen James ([JAMESH@si.edu](mailto:JAMESH@si.edu))<sup>5</sup>, Sam Rossman ([rossmans@msu.edu](mailto:rossmans@msu.edu))<sup>6</sup>

<sup>1</sup>Department of Earth Sciences, University of California, Riverside, 900 University Ave., Riverside, CA, 92404

<sup>2</sup>Department of Integrative Biology, Michigan State University, 288 Farm Lane, MI, 48824, USA

<sup>3</sup>Department of Biology, University of Akron, 185 East Mill St., Akron, OH, 44325, USA

<sup>4</sup>Institute of Low Temperature Science, Hokkaido University, Kita-19, Nishi-8, Kita-ku, Sapporo 060-0819, Japan; <sup>5</sup>Japan Agency for Marine-Earth Science and Technology, 2-15 Natsushima-cho, Yokosuka, 237-0061, Japan

<sup>6</sup>Department of Vertebrate Zoology, National Museum of Natural History, Smithsonian Institution, P.O. Box 37012, 10th Street and Constitution Avenue NW, Washington, D.C., 20560

<sup>7</sup>Hubbs-SeaWorld Research Institute, 3830 S. Highway A1A #4-181, Melbourne Beach, FL 32951

We document differences in foraging habits among Newell's shearwater (*Puffinus newelli*), Laysan albatross (*Phoebastria immutabilis*) and Hawaiian petrel (*Pterodroma sandwichensis*) using amino acid  $\delta^{13}\text{C}$ ,  $\delta\text{D}$  and  $\delta^{15}\text{N}$  analyses. Our isotope chronologies extend back as far as 100 years for the first two species, and thousands of years for the Hawaiian petrel.

$\delta^{15}\text{N}$  proxies for nutrient regime use (e.g. nitrogen supplied by marine nitrate vs. nitrogen fixation) and trophic position reveal that all three species have exhibited persistent foraging segregation and have experienced a significant trophic decline (probability  $\geq 0.97$ ) within the past 100 years. By generating  $\delta\text{D}$  and  $\delta^{13}\text{C}$  fingerprints, rarely investigated outside primary producers or in marine systems, we explore dietary explanations behind the unexpected variation found in whole tissue  $\delta\text{D}$  among these oceanic seabirds, and investigate whether  $\delta^{13}\text{C}$  values of 6 essential and 6 nonessential amino acids reveal new information about foraging location or diet in marine predators.

Information regarding foraging habits is necessary for conservation managers to assess at-sea risks and is especially critical for endangered species like the Hawaiian petrel and Newell's shearwater, which have experienced steep population declines in recent decades. Our study directs us to the perspective that a marked trophic decline was indiscriminate, affecting three Pacific seabird species that have distinct feeding strategies and population dynamics, and exhibit several other divergent morphological and behavioral traits. Collectively, our comprehensive isotopic approach provides much needed insight into the foraging habits and diets of these wide-ranging seabirds.

#### DOCUMENTATION OF ENDANGERED 'UA'U (*PTERODROMA SANDWICHENSIS*) ON MAUNAKEA, FIRST RECORD SINCE 1963

Bret Mossman ([bretnm@hawaii.edu](mailto:bretnm@hawaii.edu))\*, Ann Tanimoto-Johnson ([annmt@hawaii.edu](mailto:annmt@hawaii.edu)), Patrick Hart ([pjhart@hawaii.edu](mailto:pjhart@hawaii.edu)), and Fritz Klasner ([fklasner@hawaii.edu](mailto:fklasner@hawaii.edu))<sup>1,2</sup>

<sup>1</sup>University of Hawai'i at Hilo  
<sup>2</sup>Office of Maunakea Management

Seabirds have experienced global declines around the world and many have been pushed to the brink of extinction. In Hawai'i the 'ua'u (*Pterodroma sandwichensis*) has declined dramatically since the arrival of humans in the islands. Once distributed across the archipelago 'ua'u now only remain in a few isolated populations and number in the low thousands. Historically breeding populations of these birds persisted on Maunakea as late as 1953 but no records of the birds on the mountain have been reported since 1963. To locate possible remnant populations of 'ua'u

we used a truck mounted radar to identify areas with possible bird activity and placed an array of acoustic recorders in likely locations to pick up vocalizations. Radar was largely carried out in the summer and fall of 2017 and acoustic monitoring was completed in spring and summer 2018. From April to September 2018, 'ua'u were detected at three different locations on Maunakea. Calls were detected on several different nights from June through August at one location indicating the possible presence of breeding individuals. More on the ground surveying is needed to identify if remnant populations of 'ua'u persist on Maunakea but this study has provided promising evidence that the birds have either persisted or recolonized through a 60-year absence.

#### FORAGING MOVEMENT AND DIET OF TWO SYMPATRICALLY-BREEDING TERN SPECIES ON COUNTRY ISLAND, NS

Avery Nagy-MacArthur ([averynagy@gmail.com](mailto:averynagy@gmail.com))\* and Mark Mallory ([mark.mallory@acadiau.ca](mailto:mark.mallory@acadiau.ca))<sup>1</sup>

<sup>1</sup>Acadia University, 15 University Avenue, Wolfville, NS, B4P 2R6, Canada

Colonial-nesting seabirds may exhibit niche partitioning of diet or habitat to reduce competition and maximize resource use. Breeding seabirds require separate habitats for nesting and foraging, hence understanding marine habitat use beyond the colony is essential for effective conservation. GPS tracking technology has been successfully used to track movement of larger seabirds, but has only recently been available for tracking tern-sized seabirds. Country Island, Nova Scotia, hosts regionally significant numbers of breeding Arctic Tern (*Sterna paradisaea*) and Common Tern (*Sterna hirundo*), and although a monitoring program has existed since 1998, knowledge gaps exist regarding marine habitat use and diet of adult terns. This project integrates diet analysis with GPS tracking to generate new insight into relationships between habitat use and diet in Arctic and Common Terns, and assess interspecific spatial or dietary partitioning. I am tracking Arctic and Common Terns during incubation in 2018 and 2019 to identify foraging ranges and determine habitat use in relation to oceanographic features. I am also using stable isotope analysis of tern blood plasma and collected prey items to investigate interspecific dietary partitioning during the tracking period. Preliminary results suggest both species forage farther from the colony than previously thought and exhibit some

spatial partitioning, with Arctic Terns foraging farther offshore than Common Terns. As the first GPS-tracking study of Arctic and Common Terns in a Canadian colony, this study will provide novel baseline data on dietary and habitat requirements, key information required for marine spatial planning and conservation activities in Atlantic Canada.

#### POPULATION TRENDS OF STREAKED SHEARWATERS IN SASU ISLAND, UNDER HIGH PREDATION RISK

Ki-Baek Nam (k.b.nam1002@gmail.com)\*, Jong-Sung Son (buge99@hanmail.net), Jae-Woong Hwang (hjwbird@daum.net), and Jeong-Chil Yoo (jcyoo@khu.ac.kr)

Dep. of Biology & Korea Institution of Ornithology, Kyung Hee University, 26 Kyungheedaero-ro, Dongdeamun-gu, Seoul, South Korea 02447

Introduced predators are one of the main threats to island avifauna because island avifauna is particularly vulnerable to predation by introduced species due to the absence of the native mammalian predator. Especially, invasive rats severely impact on seabirds, reducing their populations and in many cases triggering their extinction. Nowadays, the biggest threat to the Korean seabird colonies is from introduced predatory mammals such as rats, domestic cats and dogs. In particular, *Rattus spp.* is the invasive species with the greatest impact on the seabird breeding population of South Korea. This study had been carried out at 2001-2002, 2012-2016 breeding season at the Sasu island, one of the biggest seabird colony in South Korea, to investigate the breeding success and population trend of streaked shearwaters (*Calonectris leucomelas*). In our results, breeding success has been low during all study years, and Norway rats (*Rattus norvegicus*) has been the single greatest cause of the breeding failure. However, we found that the breeding population was not likely to decline. Our result showed that the breeding population was estimated at about 15,000 breeding pairs in 2001 and about 16,000 breeding pairs in 2016. Therefore, we suggest that the breeding population has not been changed. Although rats' predation has been affecting the breeding success, the high predation by rats is not likely to drive the decrease of breeding population of streaked shearwaters in Sasu Island. We need a further study for considering the possible causes for the maintenance of the breeding population of streaked shearwaters in Sasu Island.

#### USING AGE TO ASSESS RETENTION TIME OF INGESTED PLASTIC IN SEABIRDS

Tessa Nania (tnania@pugetsound.edu)\*, Gary Shugart (gshugart@pugetsound.edu), and Peter Hodum (phodum@pugetsound.edu)

University of Puget Sound, 1500 N Warner Street, Tacoma, WA USA 98416

For the past 30 years, plastic pollution research has used plastic ingested and retained in seabirds' gastrointestinal tract (GIT) as indicators of pollution on different spatial and temporal scales. However, the length of time that birds retain plastic is unknown, making the use of ingested plastic as bioindicators questionable. Addressing retention time of plastic is problematic due to difficulties in controlling factors related to uptake, morphology, and the plastisphere the birds exist or move through. In natural situations, juvenile birds have a known time for ingesting plastic (fledging to death) while adults have an unknown time. We predicted that if retention times were long, the adults would have smaller and greater density of plastic than juveniles due to grinding in the GIT wearing down pieces. If retention times were short, the size and density of plastic pieces would be similar in adults and juveniles. We studied two seabird species, the Northern Fulmar (*Fulmarus glacialis*) and the Cassin's Auklet (*Ptychoramphus aleuticus*) using volume and density of individual pieces of plastic in ventriculi. Plastic from two fulmars age classes were similar size, suggesting that fulmars do not retain plastic for long. Adult auklets' GIT contained smaller pieces than juveniles, indicating adults retain plastic beyond the approximate four month period that juvenile were exposed to plastic. If larger samples of birds can be obtained from one place and time, comparison of juveniles, with known periods of exposure to plastic to other ages provides a comparative approach to the assessing retention for consideration of biological significance and for use as bioindicators.

#### MEASURING RELATIVE DISTURBANCE RISK TO MARINE WILDLIFE IN NORTHERN CALIFORNIA

Claire Nasr (cmn15@humboldt.edu)\*, Daniel C. Barton (daniel.barton@humboldt.edu), and Shannon Brinkman (shannon.brinkman@fws.gov)

<sup>1</sup>Humboldt State University, 1 Harpst Street, Arcata, CA USA 95521

<sup>2</sup>Bureau of Land Management Arcata Field Office, 1695 Heindon Road, Arcata, CA USA 95521

Rocky coastlines incur high impacts from human use, and marine wildlife use these same coastlines to breed, rest, and engage in social interaction, creating risk of disturbance that can be difficult to quantify. Peak timing of human use occurs in spring/summer, coinciding with breeding seasons for colonial seabirds and gregarious pinnipeds. The high potential of spatial and temporal overlap between human and marine wildlife use of rocky coastlines could lead to high risk of disturbance events such as flushing individuals from nests or separating mom-pup pairs. We measured the relative risk of disturbance to 8 species of seabirds and pinnipeds from human use to inform science-based cooperative management in areas where humans and wildlife overlap. We estimated space sharing between marine wildlife and human use activities using utilization distributions and spatial overlap methods, including the volume of intersection (VI) test statistic in Trinidad, California. Preliminary results indicated moderate space sharing between Western Gull (*Larus occidentalis*), Harbor Seal (*Phoca vitulina*) and human use (VI score = 0.463, 0.318 respectively). This method allows relative comparison of risk across species and human use types and identification of “hotspots” of risk via overlay of the utilization distributions. This project will identify targeted management areas, provide a risk assessment based on seasonal use patterns, and help target specific user groups for education, outreach and enforcement for marine wildlife protection. The analytical approach described and applied here may be broadly applicable to other situations where a quantitative approach to measuring disturbance is needed for management.

#### QUANTIFYING TOP DOWN EFFECTS OF BALD EAGLE (*HALIAEETUS LEUCOCEPHALUS*) DISTURBANCES ON A COMMON MURRE (*URIA AALGE*) COLONY

Alyssa Nelson ([nelsaaly@oregonstate.edu](mailto:nelsaaly@oregonstate.edu))<sup>1\*</sup>, Jane Dolliver ([jane.dolliver@oregonstate.edu](mailto:jane.dolliver@oregonstate.edu))<sup>2</sup>, Rachael A. Orben<sup>3</sup> ([rachael.orben@oregonstate.edu](mailto:rachael.orben@oregonstate.edu)), Robert M. Suryan ([rob.suryan@oregonstate.edu](mailto:rob.suryan@oregonstate.edu))<sup>4</sup>, Don Lyons ([lyonsd@oregonstate.edu](mailto:lyonsd@oregonstate.edu))<sup>2</sup>

<sup>1</sup>Department of Agricultural Sciences, Oregon State University

<sup>2</sup>Department of Fisheries and Wildlife, Oregon State University, 104 Nash Hall, Corvallis, OR 97331, USA

<sup>3</sup>Department of Fisheries and Wildlife, Oregon State University, Hatfield Marine Science Center, 2030 SE Marine Science Drive, Newport, OR 97365, USA

<sup>4</sup>NOAA Fisheries, Alaska Fisheries Science Center, Auke Bay Laboratories, 17109 Pt. Lena Loop Rd., Juneau, AK 99801, United States.

Seabird colonies in the Pacific Northwest continue to adapt to the 20-fold increase in bald eagle (*Haliaeetus leucocephalus*) populations in the contiguous United States. We investigated the impact of bald eagle disturbance on the largest common murre (*Uria aalge*) colony in Oregon, at Yaquina Head Outstanding Natural Area (Newport, OR). Across four years, May-July, 2015-2018, we closely monitored nest contents for approximately 180 common murre within a colony of ~60,000 individuals. During these reproductive plot checks we recorded the duration, cause, and impact of all predation events across approximately 250 person-hours/year. Adult and sub-adult eagles perpetrate predation events in about equal numbers, resulting in few adult murre killed, but secondary scavenging by gulls resulted in large egg losses. In years of poor food availability (2016 and 2017), murre abandoned early, and the impact to adults and eggs sharply decreased throughout the season. In 2015 and 2018, Yaquina Head murre were able to withstand high numbers of eagles and gulls and still produce young, suggesting that the bottom-up factors like food supply are important in determining murre reproductive success. Egg loss was the most significant, immediate impact of disturbance on the Yaquina Head Outstanding Natural Area common murre colony.

#### INVESTIGATING ALEUTIAN TERN BREEDING ECOLOGY IN WESTERN ALASKA TO INFORM FUTURE STATEWIDE SURVEYS

Kelly Nesvacil ([kelly.nesvacil@alaska.gov](mailto:kelly.nesvacil@alaska.gov))<sup>1\*</sup>, Donald E. Lyons ([dlyons@audubon.org](mailto:dlyons@audubon.org))<sup>2</sup>, Susan Oehlers ([soehlers@fs.fed.us](mailto:soehlers@fs.fed.us))<sup>3</sup>, and Grey W. Pendleton ([grey.pendleton@alaska.gov](mailto:grey.pendleton@alaska.gov))<sup>1</sup>

<sup>1</sup>Alaska Department of Fish and Game, Division of Wildlife Conservation, 1255 W. 8<sup>th</sup> Street, Juneau, AK, USA 99801

<sup>2</sup>National Audubon Society Seabird Restoration Program and Department of Fisheries and Wildlife, Oregon State University, 104 Nash Hall, Corvallis, OR, USA 97331

<sup>1</sup>U.S. Forest Service, Tongass National Forest, Yakutat Ranger District, 712 Ocean Cape Road, Yakutat, AK, USA 99689

During the 2017 and 2018 breeding season we deployed satellite telemetry tags on Aleutian terns (*Onychoprion aleuticus*) in the vicinity of Dillingham, Alaska. Local scale movements were noted in both years and were primarily within 150 km of the tagging site, although locations extended up to 300 km away. Within this region, we found previously undocumented Aleutian tern colonies in both 2017 and 2018 using location data from tagged individuals. We conducted opportunistic flights to all colonies found in 2017, and in 2018, flights to colonies found in either year. Nesting attempts at the capture site outside Dillingham were short-lived, but tagged individuals led us to colonies elsewhere that did fledge young, suggesting that later initiated nesting efforts and/or renesting may be important contributors to the population's productivity in this region. During flights to locations suggested by tracking data, we discovered additional areas of nesting and loafing, which suggests that aerial flights may be more useful than expected and an additional tool to identify previously unknown colonies. Identifying patterns of colony occupancy within and between seasons can help interpret historical Aleutian tern colony data, as well as assist in planning a future state-wide monitoring effort.

#### CHALLENGES AT SEA: DO SUSTAINABILITY STANDARDS BENEFIT SEABIRDS?

Hannah Nevins ([hnevins@abcbirds.org](mailto:hnevins@abcbirds.org))<sup>1</sup> and Holly Goyert<sup>2</sup>

<sup>1</sup>American Bird Conservancy 190 Benito Ave., Santa Cruz, California 95062

<sup>2</sup>Bird-Smart Wind Energy Campaign Director, American Bird Conservancy, 4301 Connecticut Ave, NW, Suite 451, Washington, D.C. 20008

Green economy is transforming our uses of landscape and seascapes, creating challenges on land and at sea for wildlife while meeting human needs. In the last 40 years, industrial extraction of fish for a growing human population has challenged the seabird community to find solutions for bycatch, and over-exploitation. On the horizon is industrial production of ocean energy resources is an emerging threat to seabirds. For example, offshore wind energy farms are proposed for call areas in California, Hawaii and in the Atlantic US. Meanwhile there are multiple politically-driven

sustainability goals and targets for green energy. Among the environmental community there is support for these efforts to combat climate change through responsible renewable energy development, and we will be challenged to find solutions where seabirds and wind power can co-exist. We propose a bird smart framework for the offshore wind industry to adopt practices and standards that protect birds, sets up mitigation funds, and includes appropriate engagement and oversight by the scientific and conservation communities. These standards should include: site-specific research and predictive mapping to carefully site wind energy facilities in locations that avoid bird 'hotspots' (important foraging or staging areas, migratory paths); determine whether there are any high risk areas within the call areas that should be excluded; implementation of an avian monitoring and minimization plan that is subject to public review; and efforts should also be made to foster the innovation of detection and deterrent technology.

#### DIVING IN! FIRST REPORT OF THE UNDERWATER BEHAVIOR OF CHRISTMAS SHEARWATERS (*PUFFINUS NATIVITATIS*) ON KURE ATOLL

Ilana Nimz ([inimz@my.hpu.edu](mailto:inimz@my.hpu.edu))\* and K. David Hyrenbach ([khyrenbach@hpu.edu](mailto:khyrenbach@hpu.edu)):

<sup>1</sup>Hawaii Pacific University, 41-202 Kalaniana'ole Highway, Waimanalo, Hawai'i 96795

Morphologically, the Christmas shearwater (*Puffinus nativitatis*) is a highly-aquatic tropical shearwater with laterally compressed tarsi and a high wing loading for its body mass. While this species engages in pursuit plunging and diving, there are no published reports quantifying their sub-surface foraging behavior. We obtained information from Lotek-1500 time-depth-recorders deployed on eight chick-rearing Christmas shearwaters on Kure Atoll, during June-August of 2017. We recorded 1,519 dive events during thirty-three tagging days. Individual deployment durations ranged from three to eight days, and were independent from the maximum depth attained ( $r=0.004$ ). Individual maximum depths ranged from 10.7 to 24.1 meters, with a mean of 15.4  $\pm$  4.2 S.D. meters. While the deepest and longest recorded dive reached 24 meters and lasted 31 seconds, the majority of the dives were shallower than three meters (64%), and lasted three seconds or less (53%). Overall, deeper dives were longer ( $r = 0.910$ ). Diving occurred exclusively during daylight hours, with peak hourly diving activity (13%) during the evening (1700-1800

HST). This study provides the first insights into the diving behavior of the Christmas Shearwater, and highlights the epipelagic foraging habitat of this species of concern within the Papahānaumokuākea Marine National Monument.

#### WHAT'S IN A PELLET? A DIET ANALYSIS OF DOUBLE-CRESTED CORMORANTS USING PELLETS IN SOUTH HUMBOLDT BAY, CA

Karen Oakden (karen.oakden15@gmail.com)<sup>1\*</sup>  
1Department of Wildlife, Humboldt State University,  
1 Harpst St. Arcata, CA 95521, USA

There are many different reasons to study diets with various species around the world. You can understand population dynamics using the predators' diet or help with the management of endangered species by finding the prey species. Double-crested cormorants (*Phalacrocorax auritus*) are known to be primarily piscivorous. Starting about a decade ago, there have been conflicts between Double-crested cormorants and endangered species of Salmonids around East Sand Island in Oregon. I wanted to know if prevalent predation with the Teal Island Double-crested cormorant colony and the endangered Salmonid species in South Humboldt Bay, CA. I dissected 21 pellets collected from the Humboldt Bay National Wildlife refuge and identified otoliths and other pieces of organisms. Ultimately I found that this colony had been eating about equal portions of fish and decapods. Within the fish species I found that the Double-crested cormorants ate primarily rockfish (*Sebastes* sp.) followed by Chinook Salmon (*Oncorhynchus tshawytscha*) and Coho Salmon (*Oncorhynchus kisutch*). This could lead to possible management plan being instituted on the double-crested cormorants in Humboldt Bay, due to the somewhat high amount of endangered Salmonids in Humboldt Bay. However, the possible management plan should be fairly mild because the cormorants were eating a large amount of decapods and rockfish.

#### ANCESTRAL AND CONTEMPORARY BIOCULTURAL INTERACTIONS BETWEEN ALBATROSSES AND HUMAN BEING IN THE SUB-ANTARCTIC REGION

Jaime Ojeda ([jaimeojedavillarroel@yahoo.es](mailto:jaimeojedavillarroel@yahoo.es))<sup>1,2,3\*</sup> and  
Cristián G. Suazo<sup>4</sup>

<sup>1</sup>School of Environmental Studies, University of Victoria, Victoria, Canada.

<sup>2</sup>Instituto de Ecología & Biodiversidad, Casilla 653, Santiago, Chile.

<sup>3</sup>Laboratorio de Macroalgas Antárticas y Subantárticas (LMAS), Casilla 113-D, Universidad de Magallanes, Punta Arenas, Chile

<sup>4</sup>Department of Animal Ecology and Systematics, Justus Liebig University Giessen, Heinrich-Buff-Ring 38, 35392 Giessen, Germany

Chilean Sub-Antarctic ecoregion holds around 20% of black-browed albatrosses' (BBA; *Thalassarche melanophrys*) world population. This has enormous ecological and cultural importance. For example, since 6,000 before present, indigenous people (Yagan culture) have been profoundly related to albatrosses by ecological indicators, traditional food, ceremonial and spiritual proposes. Today, this albatrosses-human link continues in different forms in the Sub-Antarctic region. For instance, albatrosses feed the hake fishery's offal. Even, this socio-ecological footprint has been found in albatrosses' colonies where fishing's offal seems to be one of the most important feeding items. One relevant aspect is that artisanal hake fishery has a low negative impact, especially in seabirds' incidental capture. This albatrosses-artisanal fishers' relationship has a substantial difference if we compare it with industrial operations in the Southern Ocean, where still there are high mortality of seabirds. In turn, artisanal fishers mention to have a positive perception of seabirds because they are useful indicators of marine productivity. In several occasions, artisanal hake fishery can generate win-win biocultural interactions, in where the fishermen use the flock of birds as ecological indicators, and seabirds feed of the discards (offal) associated with fishing operations. Taking into account the ancestral and contemporary albatrosses-fishers relationship, we aim to make a review with ecological, historical, social information. That is why our target has three sources: ethnographical literature, semi-interviews, ecological data in order to describe the albatrosses-fishers relationship. In conclusion, we want to show a biocultural approach to contribute a stewardship management and biocultural conservation in the Sub-Antarctic region.

## SAMPLING THEIR SURROUNDINGS: USING SEABIRDS AS OCEANOGRAPHIC SAMPLING PLATFORMS

Rachael A. Orben (raorben@gmail.com)<sup>1\*</sup>, Adam Peck-Richardson (peckrichardson@gmail.com)<sup>2</sup>, Don Lyons (Don.Lyons@oregonstate.edu)<sup>3</sup>, Jim Lerczak (jlerczak@coas.oregonstate.edu)<sup>3</sup>

<sup>1</sup>Department of Fisheries and Wildlife, Oregon State University, Hatfield Marine Science Center, 2030 SE Marine Science Dr., Newport, OR 97365, USA

<sup>2</sup>Department of Fisheries and Wildlife, Oregon State University, 104 Nash Hall, Corvallis, OR 97331, USA

<sup>3</sup>College of Earth, Ocean, and Atmospheric Sciences, Oregon State University, 104 CEOAS Administration Building, Corvallis, OR 97331, USA

Seabirds use a diversity of marine habitats and offer unprecedented access to dynamic environments in the surface ocean. However, there are few examples of biologging devices carried by seabirds being used to collect data about surrounding conditions that are then integrated into larger earth monitoring networks. To effectively use seabirds as oceanographic sampling platforms further innovations in miniaturization and sensor design are needed to develop tags that are <3% of body mass (ideally <1% for long duration deployments), and diversify the data being collected from birds. We are currently developing methods of data collection and processing to integrate seabird derived *in situ* data in oceanographic models. Our goal is to deploy cormorants with CTD tags carrying fast response temperature and conductivity sensors to make water column measurements during foraging dives. Benthic dives, characterized by flat bottom dive profiles, will be used as depth soundings and tags carrying 3-axis accelerometers and magnetometers will be used to measure wave height, period, and direction. Finally, GPS locations during surface intervals will be used to estimate surface currents. This integrated research approach should lead to new insights into seabird foraging ecology in relation to fine-scale environmental conditions. Identifying viable and practical uses for seabird biologging data, in addition to ecological and conservation needs of seabirds, offers opportunities for multidisciplinary science and maximizes the use of data from these loggers.

## PHTHALATE EXPOSURE IN BERING SEA SEABIRDS

Veronica M. Padula (vmpadula@alaska.edu)<sup>1,2\*</sup>, Birgit Hagedorn (birgit.hagedorn@searchLC.com)<sup>3</sup>, Anne Beaudreau (abeaudreau@alaska.edu)<sup>3</sup>, and Douglas Causey (dcausey@alaska.edu)<sup>1,2</sup>

<sup>1</sup>Department of Biological Sciences, University of Alaska Anchorage, Anchorage, AK 99508

<sup>2</sup>College of Fisheries and Ocean Sciences, University of Alaska Fairbanks, Juneau, AK 99801

<sup>3</sup>Sustainable Earth Research LLC, Anchorage, AK 99508;

The plastic debris that enters the Pacific Ocean eventually reaches Bering Sea ecosystems, and many researchers are investigating the potential impacts of plastics on the physical environment and organisms in the Bering Sea. Specifically, seabirds and the prey upon which they feed may come into contact with plastics in several ways. They may mistake plastic debris for food items and ingest them, may become entangled in plastic debris or may incorporate debris into nests. Birds are consequently exposed to numerous plastic-associated chemical adjuncts, particularly endocrine-disrupting compounds like phthalates. We aim to build a foundation of knowledge of phthalate exposure in Bering Sea seabirds that leads to better understanding their correlative effects on ecosystem health. Our study has two objectives: (1) Describe occurrence of plastic particles in seabird stomachs and concentrations of phthalates in seabird tissues; and (2) Quantify variation in patterns of exposure by geographic location, year, feeding/foraging, and species. We analyzed 6 phthalate congeners, and  $\delta^{13}\text{C}/\delta^{15}\text{N}$  stable isotopes from 111 individuals, representing nine seabird species that breed in the Bering Sea ecosystem. ANCOVA analyses and preliminary non-parametric multi-dimensional scaling analyses show no clear and geographic patterns of exposure, but ANCOVA analyses suggest that species or foraging behavior may influence risk of phthalate exposure. This suggests that these plastic-associated chemicals are distributed throughout the Bering Sea ecosystem, and that a large proportion of seabird species breeding within the region are at risk of exposure, although some species, such as planktivorous auklets, may be at higher risk of exposure than others.

A (12-MINUTE) REVIEW OF NEARLY 5-DECADES OF CALIFORNIA BROWN PELICAN BREEDING PERFORMANCE AT CHANNEL ISLANDS NATIONAL PARK, 1969 - 2018

Michael Parker ([mike.parker@ciesresearch.org](mailto:mike.parker@ciesresearch.org))\*, Frank Gress ([fgress@ciesresearch.org](mailto:fgress@ciesresearch.org)), Jim Howard ([jim.howard@ciesresearch.org](mailto:jim.howard@ciesresearch.org)), David Mazurkiewicz ([david.mazurkiewicz@nps.gov](mailto:david.mazurkiewicz@nps.gov)), Amelia DuVall ([amelia\\_duvall@ciesresearch.org](mailto:amelia_duvall@ciesresearch.org)), Peter Larramendy ([pt70027@gmail.com](mailto:pt70027@gmail.com)), Katy Carter ([katy.carter@ciesresearch.org](mailto:katy.carter@ciesresearch.org)), Dan Anderson ([dwanderson@ucdavis.edu](mailto:dwanderson@ucdavis.edu)), and Andrew Yamagiwa ([andrew\\_yamagiwa@ciesresearch.org](mailto:andrew_yamagiwa@ciesresearch.org))

<sup>1</sup>California Institute of Environmental Studies

<sup>2</sup>Channel Islands National Park

After being listed under the U.S. Endangered Species Act in 1970, the California brown pelican (*Pelecanus occidentalis californicus*) breeding subpopulation within the Channel Islands National Park increased nesting effort and nesting success from the late-1970s through the mid-2000s. The pelican was delisted in 2009 and breeding populations appeared to immediately decline, although monitoring efforts were limited. Since 2014, increased censusing effort has recorded nesting effort and reproductive success at levels observed in the late 1990s and early 2000s. A major difference in breeding performance over the last 48-year span appears to be timing of breeding. The pelican nesting season has been protracted in recent years with nest initiation occurring earlier and extending later than previously recorded. Environmental conditions impacting observed trends may include changes in prey resources and impacts of climate change. We briefly discuss the importance of the Southern California Bight subpopulation in relation to factors impacting other California brown pelican subpopulations (e.g., Gulf of California). While the Southern California Bight population is estimated to represent less than 20% of the metapopulation, the above average chick production in recent years is likely playing an important role in maintaining the population, particularly as the larger subpopulation in the southern Midriff region of the Gulf of California has experienced near reproductive failure over the past five years.

HABITAT UTILIZATION OF MARBLED MURRELETS IN HAIDA GWAI, BC: USING LONG-TERM AND ADDITIONAL DATA FROM LASKEEK BAY

Sonya Pastran ([sonya\\_pastran@sfu.ca](mailto:sonya_pastran@sfu.ca))\*, David Lank ([dlank@sfu.ca](mailto:dlank@sfu.ca))<sup>2</sup> and Ronald Ydenberg ([ronald\\_ydenberg@sfu.ca](mailto:ronald_ydenberg@sfu.ca))<sup>2</sup>

<sup>1</sup>Simon Fraser University, 8888 University Drive, Burnaby British Columbia V5A 1S6

<sup>2</sup>Laskeek Bay Conservation Society, 6-848 Highway 16, Skidegate, B.C. Canada. V0T 1S1

Marbled Murrelets (*Brachyramphus marmoratus*) nest high in the canopies of old growth coniferous trees but spend the majority of their lives on water. In Canada, they are listed as threatened, with their numbers apparently continuing to drop. Both terrestrial and marine habitats are vital for survival and reproduction. No marine habitat association studies have been conducted in the northern coastal islands of Haida Gwaii, BC. I am using archived and ongoing at-sea monitoring data collected by the Laskeek Bay Conservation Society along fixed transects (1990-2017) plus additional data (2018 and 2019) to (1) map out their annual and interannual local abundance and distribution along transect lines, defining hot- and coldspots and annual variability, (2) test for relationships between at sea usage and static and dynamic oceanographic variables obtained from existing environmental databases, and (3) examine fine-scale distributional relationships with respect to dynamic variables, including local prey abundance/availability and the effect of avian predation, based on 2018 and 2019 data; Prey abundance and fine-grained environmental variables of interest are being collected on the same routes as the at-sea bird surveys. The effect of avian predation danger was measured experimentally using replica raptor kites along the shoreline of Louise Island Murrelet counts along nearshore transects were on average 30% lower when kites were flown. Thus, the presence of avian predators should be considered as a variable of interest when examining breeding season inshore marine habitat preferences for this Murrelet.



# USING DIGITAL VHF TELEMETRY TO MONITOR OFFSHORE MOVEMENTS OF TERNS AND PLOVERS ALONG THE ATLANTIC COAST

Alphabetized by Paton

Pamela H. Loring ([pamela\\_loring@fws.gov](mailto:pamela_loring@fws.gov)), Peter W.C. Paton ([ppaton@uri.edu](mailto:ppaton@uri.edu))\*, James D. McLaren ([jamieequal@gmail.com](mailto:jamieequal@gmail.com)), and Hua Bai ([huab@umass.edu](mailto:huab@umass.edu))<sup>‡</sup>

<sup>‡</sup>U.S. Fish and Wildlife Service, Division of Migratory Birds, Charlestown, RI, 02813

<sup>‡</sup>Department of Natural Resources Science, University of Rhode Island, Kingston RI 02881

<sup>‡</sup>Environment and Climate Change Canada, Science and Technology Branch

<sup>‡</sup>University of Massachusetts Amherst, Department of Electrical and Computer Engineering, Amherst MA 01003

We investigated offshore movements and flight altitudes of Common Terns (*Sterna hirundo*), Federally-endangered Roseate Terns (*Sterna dougallii*), and Federally-threatened Piping Plovers (*Charadrius melodus*) within the Atlantic Outer Continental Shelf. Currently, 5,492 km<sup>2</sup> is under BOEM lease agreement for commercial-scale offshore wind and an additional 12,976 km<sup>2</sup> is in the planning stages in the U.S. Atlantic. We attached digital VHF transmitters to adult Roseate Terns ( $n=150$ ), Common Terns ( $n=266$ ), and Piping Plovers ( $n=150$ ) in southern New England from 2014 to 2017. We developed 3-D movement models, estimated their exposure to BOEM Lease and Planning Wind Energy Areas (WEAs), and quantified the effects of meteorological conditions, temporal variation, and demographic variation on the occurrence of these three species in federal waters and WEAs. For terns, the highest probability of exposure occurred during post-breeding dispersal. Tern flights across Federal waters and WEAs occurred during fair weather (high atmospheric pressure) with high visibility and low precipitation. Offshore flight altitudes of terns were generally below the Rotor Swept Zone (RSZ; 20 to 200 m asl) of offshore wind turbines. Piping Plovers departed from their breeding grounds on evenings with strong supportive tail winds and primarily used offshore routes to stopover areas in the mid-Atlantic. Offshore flight altitudes of Piping Plovers generally occurred above the RSZ. The geographic coverage and scope of digital VHF telemetry can be further extended through the coordinated efforts of the Motus Wildlife Tracking System.

# WHY DO ANCIENT MURRELETS FROM THE SAME COLONIES WINTER 8000 KM APART?

Allison Patterson ([allison.patterson@mail.mcgill.ca](mailto:allison.patterson@mail.mcgill.ca))\*, Laurie Wilson ([laurie.wilson@canada.ca](mailto:laurie.wilson@canada.ca)), Yuriko Hashimoto ([yuriko.hashimoto@canada.ca](mailto:yuriko.hashimoto@canada.ca)), and Kyle H. Elliott ([kyle.elliott@mcgill.ca](mailto:kyle.elliott@mcgill.ca))<sup>‡</sup>

<sup>‡</sup>Department of Natural Resource Sciences, McGill University, 21111 Lakeshore Rd, Ste-Anne-de-Bellevue, QC, Canada

<sup>‡</sup>Pacific Wildlife Service Centre, Canadian Wildlife Service, Environment and Climate Change Canada, 5421 Robertson Rd, Delta, BC, Canada

Latitudinal migration in seabirds usually tracks seasonality in marine resources, while the causes of longitudinal migration are more obscure. Optimizing energy intake or expenditure are two potential explanations. Ancient murrelets (*Synthliboramphus antiquus*) that breed in Haida Gwaii, Canada, can use one of two migration strategies. Adults travel north to moult in the Bering Sea in late summer, and then birds either travel west, to winter in the Japan and Yellow Seas, or return to the Eastern Pacific to winter along the West Coast of North America. We tracked 46 ancient murrelets using light-level geolocators in 2014-15; 72% (33) of birds wintered in the Western Pacific and 28% (13) returned to the Eastern Pacific. We examined differences in habitat use for murrelets in these two regions, to explore potential drivers and consequences of this unusual migration pattern. Murrelets wintering in the west were farther south (38° vs 51°N). There were no differences in average SST between the two regions, which is consistent with patterns of ocean circulation in the North Pacific; however, murrelets wintering in the west used areas with greater variation in SST (2.3 vs 0.8°C). Murrelets in the west also used areas with deeper water (608 m vs 136 m), were farther from the coast (52 vs 3 km), and experienced higher average wind speeds (7.4 vs. 4.7 km/hr). Given these difference in habitat use, we propose that murrelets using these two regions face different constraints during winter, specifically in terms of energetic costs and predation risk.

# INVESTIGATING ANCIENT MURRELET MOVEMENT DURING THE BREEDING SEASON USING GPS TAGS AT A COLONY IN HAIDA GWAI, BRITISH COLUMBIA, CANADA

Vivian Pattison ([pattison@uvic.ca](mailto:pattison@uvic.ca))<sup>‡\*</sup>, Laurie Wilson ([laurie.wilson@canada.ca](mailto:laurie.wilson@canada.ca)), Dan Shervill

(dan.shervill@canada.ca)<sup>3</sup>, Patrick O'Hara (paddio@uvic.ca)<sup>3,4</sup>, Christopher Bone (chrisbone@uvic.ca)<sup>1</sup>, and Laura Cowen (lcowen@uvic.ca)<sup>5</sup>

<sup>1</sup>Department of Geography, University of Victoria, PO Box 1700 STN CSC, Victoria, BC Canada, V8W 2Y2

<sup>2</sup>Laskeek Bay Conservation Society, Queen Charlotte, BC Canada, V0T 1S0

<sup>3</sup>Canadian Wildlife Service, Pacific Wildlife Research Centre, RR1 5421 Robertson Road, Delta, BC Canada, V4K 3N2

<sup>4</sup>Canadian Wildlife Service, Institute of Ocean Sciences, 9860 W Saanich Rd, Sidney, BC Canada, V8L 4B2

<sup>5</sup>Department of Mathematics and Statistics, University of Victoria, PO Box 1700 STN CSC, Victoria, BC Canada, V8W 2Y2

The Ancient Murrelet (*Synthliboramphus antiquaas*) is a seabird of conservation concern, with half of its global population breeding on forested islands throughout the Haida Gwaii archipelago in Canada. Recent studies have identified non-breeding areas and migration routes of these birds using light level geolocation telemetry. Now, with the availability of lighter-weight GPS logging devices we are investigating localized movement and behavior patterns during the breeding season. Here, we present the preliminary results of a GPS tagging study from one colony in south-east Haida Gwaii. Twenty-six individuals were tagged during incubation at their burrows in the Ramsay Island colony. Six loggers were successfully recovered and the tracks demonstrated that adults travel much farther during one foraging trip than previously suspected. They were found to be travelling large distances throughout Hecate Strait, up to 140 km from their nest sites, and often eastwards towards the mainland coast which is contrary to what was anticipated. Other burrow-nesting seabirds breeding in a similar area were found to travel away from the mainland coast towards the continental shelf-break during foraging expeditions. In order to understand foraging range and behaviour of Ancient Murrelets, parameters such as total foraging trip distance, maximum distance travelled, and maximum speed were calculated. Methods such as residence in space and time and hidden Markov models were implemented to categorize behaviour and determine if foraging locations can be identified from GPS tracks. Results will be used by the Canadian Government in support of their Ocean Protection Plan and successful management of this species under the Species at Risk Act.

## SEASONAL AND ANNUAL CHANGES IN MARBLED MURRELET ABUNDANCE AND DISTRIBUTION IN PUGET SOUND

Scott F. Pearson ([scott.pearson@dfw.wa.gov](mailto:scott.pearson@dfw.wa.gov))\*

<sup>1</sup>Washington Department of Fish and Wildlife, 1111 Washington St. SE, Olympia, WA USA 98501

Long-term trends (2001-2018) suggest that the Marbled Murrelet (*Brachyramphus marmoratus*) is declining in the Puget Sound Region. In this region, it appears that both marine and terrestrial-nesting habitat factors influence changes in murrelet population abundance and distribution. To gain insights into winter distribution and abundance, we conducted fall-winter line transect surveys from the fall of 2012 through the winter of 2018. This work was funded by the U.S. Navy as part of an effort to gain a better understanding of the murrelet's on-the-water densities in areas near Puget Sound and Hood Canal Naval facilities. Preliminary results indicate that similar to spring-summer trends, murrelet density is decreasing over time, with the most pronounced fall-winter decreases occurring in Hood Canal and Admiralty Inlet regions. However, there is no apparent correlation between fall-winter and spring-summer trends, suggesting that the factors influencing population trends differ between seasons or that birds, other than just local breeders, influence the winter population. In general, murrelet density increases in the fall-winter relative to the spring/summer, but this contrast between seasons appears to be decreasing over time. Murrelet density is relatively and consistently high in November and again in March, which may reflect pre- and post-breeding movements, and is more variable in the winter (Dec – Feb). These seasonal differences in distribution and abundance suggest the need for season-specific conservation strategies in this dynamic region.

## ECOSYSTEM-LEVEL CHANGES IN THE NORTH AMERICAN TUFTED PUFFING BREEDING POPULATION

Scott F. Pearson ([scott.pearson@dfw.wa.gov](mailto:scott.pearson@dfw.wa.gov))\*, Ilai Keren ([Ilai.Keren@dfw.wa.gov](mailto:Ilai.Keren@dfw.wa.gov))<sup>1</sup>, and Peter Hodum ([phodum@pugetsound.edu](mailto:phodum@pugetsound.edu))<sup>2</sup>

<sup>1</sup>Washington Department of Fish and Wildlife, 1111 Washington St. SE, Olympia, WA USA 98501

<sup>2</sup>University of Puget Sound, Department of Biology, University of Puget Sound Tacoma, WA, 98416, USA

Regional and local studies suggest that the iconic Tufted Puffin (*Fratercula cirrhata*) is undergoing a major range contraction. However, it is possible that the North American population is contracting with little change to the overall population size. To examine population trends throughout its North American range, we assembled 11 datasets that spanned 111 years (1905-2016) and ranged in latitude from the Farallon Islands (37.70N, -123.00 W) in the south, north to Prince William Sound (60.67N, -147.43W), and west to Nizki Island (52.744N, -17.972W). These data included at-sea density or encounter estimates and on-colony counts. To assess trends, we conducted a meta-analysis for the California Current, Gulf of Alaska, and Aleutian Island large marine ecosystems. We found that the Tufted Puffin has been declining across approximately 70% of its geographical range and two of the three ecosystems assessed. Rates of decline since 2000 are greater than declines prior to 2000. At the same time, the puffin's population was increasing in the Aleutian Islands. Although not part of our analysis, our review of the literature suggests a variety of factors could be responsible for declines including warmer ocean conditions, increasing bald eagle populations, past oils spills and fisheries bycatch, and introduced mammals. Increases in the Aleutians could be the result of a release from past arctic fox predation and Japanese gill net fishery bycatch mortality, positive intrinsic growth and/or emigration from adjacent ecosystems where populations are declining.

#### CASPIAN TERN POPULATION MONITORING: 2018 UPDATE FOR THE PACIFIC COAST REGION

Adam G. Peck-Richardson (PeckRichardson@gmail.com)\*, Donald E. Lyons (Don.Lyons@oregonstate.edu)<sup>1</sup>, Timothy J. Lawes (Timothy.Lawes@oregonstate.edu)<sup>1</sup>, Daniel D. Roby (Daniel.Roby@oregonstate.edu)<sup>1</sup>, and Michelle K. D. McDowell (Michelle\_McDowell@fws.gov)<sup>2</sup>

<sup>1</sup>Oregon Cooperative Fish and Wildlife Research Unit, Department of Fisheries and Wildlife, 104 Nash Hall, Oregon State University, Corvallis, OR 97331-3803 USA

<sup>2</sup>Migratory Birds and Habitat Program, Pacific Region, U.S. Fish and Wildlife Service, 911 NE 11<sup>th</sup> Avenue, Portland, OR 97232-4181 USA

Caspian Terns (*Hydroprogne caspia*) nesting in the Columbia River basin of Oregon and Washington have

been identified as one factor limiting the recovery of several anadromous salmonid (*Oncorhynchus* spp.) populations listed under the U.S. Endangered Species Act. In response, management efforts were initiated to reduce the number of Caspian Terns nesting in the Columbia River basin and redistribute the population to other nesting locations in the Pacific Coast region. A transition from a complete census-based approach, used in past assessments, to a sampling-based approach was undertaken to reduce costs and to ensure a known ability to detect population change between assessments. Beginning in 2015, the U.S. Fish and Wildlife Service implemented this long-term regional monitoring strategy. Under this strategy, a subset of all known Caspian Tern colony sites are surveyed every three years and the regional breeding population is estimated using a dual-frame sampling-based methodology. In 2018, we completed the second region-wide survey using this approach. Based on 38 active and historical colony sites pre-selected as part of the sampling framework, we calculated a preliminary 2018 population estimate of 9,232 breeding pairs (95% confidence interval: 6,364 – 12,099 breeding pairs); not significantly different from the 2015 estimate of 10,270 breeding pairs (95% confidence interval: 7,614 – 12,926 breeding pairs). In addition, we used monitoring data from a total of 71 tern colonies in 2018 to calculate a minimum estimate of 10,580 breeding pairs; consistent with the estimate generated using the sampling framework. Both the 2015 and 2018 dual-frame sampling-based estimates are lower than pre-management complete censuses; however, available evidence suggests declines occurred prior to 2015 rather than during the recent 2015-2018 period.

#### SEABIRDS, FERAL CATS, & PEOPLE - WORKING TOWARD BALANCE, STRIVING FOR HARMONY

Jay Penniman (jayfp@hawaii.edu)<sup>1</sup>  
Christine Costales (Christine.C.Costales@hawaii.gov)<sup>2</sup>  
Dr. Fern Duvall (Fern.P.Duvall@Hawaii.edu)<sup>2</sup>

<sup>1</sup> Maui Nui Seabird Recovery Project, P.O. Box 903, Makawao, Hawai'i 96768

<sup>2</sup> Hawaii Division of Forestry & Wildlife, 1955 Main Street, #301, Wailuku, Hawai'i 96793

Seabirds were once the most numerous animals in the Hawaiian Islands. The arrival of *Homo sapiens* resulted in displacement of the majority of them from their terrestrial habitats. Habitat change and introduction of mammalian predators has driven the

decline and extinction of seabird species. In 2006 Maui Nui Seabird Recovery Project and the state of Hawai'i, Division of Forestry & Wildlife went to the island of Lāna'i to determine if there were Hawaiian petrel ('Ua'u, *Pterodroma sandwichensis*) remaining in the highlands of Lāna'ihale. That exploration resulted in documentation of, what is perhaps, the second largest remaining population of the species. It was immediately apparent that predation, primarily by feral cats (*Felis catus*), was a serious problem. On the island of Maui, colonies of Wedge-tailed shearwater ('Ua'u kani, *Ardenna pacifica*) have been constantly subject to predation by feral cats resulting in total reproductive failure in colonies where no predator control is performed. We engaged the community and the then owner of the island of Lāna'i to build a feral cat "sanctuary" where animals were removed from the landscape and placed within a fenced enclosure. On Maui, community engagement in the form of a yearlong attempt at dialogue and stakeholder position sharing failed to bring the parties to productive resolution. The Maui Humane Society maintains adherence to a trap, neuter, & return policy that provides no relief to seabirds and other native and endangered species from feral cat predation. We explore the differences in the two situations and identify important elements of the Lāna'i experience that led to success versus possible elements that have thwarted positive movement on the island of Maui.

#### ONE PETREL, ONE SHEARWATER, STORIES OF PROGRESS IN RESTORATION ON MAUI AND MOLOKAI

Jay Penniman (jayfp@hawaii.edu)<sup>1</sup>

Jenni Learned (learnedj@hawaii.edu)<sup>1</sup>

Martin Frye (mfrye@hawaii.edu)<sup>1</sup>

Karla Trigueros (ktrigueros@csmbu.edu)<sup>1,2</sup>

<sup>1</sup> Maui Nui Seabird Recovery Project, P.O. Box 903, Makawao, Hawai'i 96768

<sup>2</sup> KUPU (AmeriCorps), 677 Ala Moana Blvd, Suite 1200, Honolulu, HI 96813

Hawaiian petrel (*Pterodroma sandwichensis*, 'Ua'u) and Wedge-tailed shearwater (*Ardenna pacifica*, 'Ua'u kani) are two iconic procellariiform species of the Hawaiian archipelago. 'Ua'u are endemic to the southern seven high islands and 'Ua'u kani are indigenous to the entire archipelago. 'Ua'u are listed as endangered by the state of Hawai'i and the US Fish & Wildlife Service; the IUCN lists them as threatened. 'Ua'u kani are considered species of least concern as

their populations have not yet reached critically low numbers. However, they are in decline worldwide. On the high Hawaiian Islands 'Ua'u kani numbers are minimal and the islands may be considered sinks as they draw birds from predator free offshore islets to areas where predators and human activity result in high levels of mortality. Maui Nui Seabird Recovery Project has engaged for the past 13 years in providing support for these two species as they struggle with predation by mammalian predators for whom they have no defense mechanisms. Additionally, modifications to the habitat that these species evolved in have compounded their struggle. We describe successful methods, for predator control, limiting habitat modifying alien mammals and plants, and restoring native vegetation communities, that are showing promise for bolstering seabird survival. The project attributes many successes to engagement with state and federal agencies, community organizations and individual volunteers. Providing secure breeding sites to these and other seabird species will require additional community support and collaboration, we describe developing projects that seek to capitalize on partnerships with Hawaiian cultural practice, ecological restoration and open space preservation.

#### TO CATCH A KILLER: EFFECTIVELY TARGETING SEABIRD HUNTING CATS ON KAUAI

Kyle Pias (kpias@hawaii.edu), Alex Dutcher (dutcher@hawaii.edu)

<sup>1</sup>Hono o Na Pali NARS Seabird Mitigation Project, 1544 Haleukana, Bay 2, Lihue HI 96766

Hono O Nā Pali (HONP) Natural Area Reserve is an important breeding site for the federally threatened Newell's Shearwater (*Puffinus newelli*), the federally endangered Hawaiian Petrel (*Pterodroma sandwichensis*), and the federally endangered Band-rumped Storm-Petrel (*Oceanodroma castro*). Breeding colonies of these seabirds elsewhere on the island of Kauai face threats from anthropogenic sources such as light pollution and power-line strikes. While the colonies in HONP are relatively unaffected by such threats given the lack of human habitation and infrastructure on the northwest coast of the island, they do face predation from a variety of invasive predators. Feral cats (*Felis catus*) can be especially damaging to seabird colonies as they are wide-ranging, efficient hunters and target both adult birds and chicks alike. Cats that have learned to effectively hunt seabirds are even more difficult to manage as they

often are uninterested in traditional baits. To deal with these problem cats, we aimed to take advantage of one of the most limited resources used by these cats in the steep topography and thick vegetation of HONP; trails. We set un-baited pass-through (referred to as “blind sets”) traps in trail bottlenecks in and around five seabird colonies in HONP from 2016-2018. We found that we were three times more likely to capture a seabird-killer cat in a blind set trap than a traditionally baited trap. This suggests that trapping techniques must be target and environment specific to most effectively protect seabirds from depredation.

#### THE ECTOTHERMIC VISE: REGULATION OF SEABIRDS BY FORAGE FISH IN HOT WATER

John Piatt ([jpiatt@usgs.gov](mailto:jpiatt@usgs.gov)), Mayumi Arimitsu ([marimitsu@usgs.gov](mailto:marimitsu@usgs.gov))<sup>2</sup>

<sup>1</sup>USGS Alaska Science Center, 4210 University Drive, Anchorage, AK USA 99508

<sup>2</sup>USGS Alaska Science Center, 250 Egan Drive, Juneau, AK USA 99801

Why do we observe large die-offs of some seabirds during periods of intense ocean warming (e.g., El Niño, the “Blob”)? Temperature anomalies usually don’t impact seabirds directly because, as endotherms, they can regulate internal temperatures against external extremes. Such flexibility comes with a high cost: seabirds must eat a large mass of fish every day to fuel their fast metabolisms. Absent fuel, seabirds emaciate quickly and die within days. Occasionally, this occurs on a grand scale when large “wrecks” of seabirds occur in association with warm-water events. Such wrecks suggest a scarcity of forage fish on the same scale, and so we ask: How does warm water affect forage fish? Unlike seabirds, fish are ectotherms and very sensitive to temperature change. A large positive temperature anomaly can increase fish metabolic rate and food demands enormously. Existing food supplies may then become inadequate, leading to adult mortality or recruitment failure. Or, less of what forage fish eat may go towards growth or fat storage, thus reducing nutritional quality for predators. Elevated metabolic and food demands of large predatory fish, which typically out-consume seabirds by >10:1 on shelf systems, intensifies competition with seabirds for forage fish. The entire ectothermic food web, from small zooplankton to large predatory fish is profoundly affected by warm anomalies, tightening bottom-up constraints on prey biomass and quality, and loosening control of top-down consumption. This

creates an “ectothermic vise” on intermediate taxa whose dual role as predator and prey increases simultaneously. In short, it appears that extreme ocean warming promotes wasp-waist regulation of seabirds in high latitude marine ecosystems.

#### UPDATE ON ALBATROSS POPULATION MONITORING AT MIDWAY ATOLL NWR

Jonathan Plissner ([jonathan.plissner@islandconservation.org](mailto:jonathan.plissner@islandconservation.org))<sup>1</sup>, Kelly Goodale ([kelly\\_goodale@fws.gov](mailto:kelly_goodale@fws.gov))<sup>2</sup>, Beth Flint ([beth\\_flint@fws.gov](mailto:beth_flint@fws.gov))<sup>3</sup>, William Kendall ([William.Kendall@colostate.edu](mailto:William.Kendall@colostate.edu))<sup>4</sup>, Roberta Swift ([roberta\\_swift@fws.gov](mailto:roberta_swift@fws.gov))<sup>5</sup>

<sup>1</sup>Island Conservation, USFWS Midway Atoll NWR, 1082 Makepono St., Honolulu, HI USA 96819

<sup>2</sup>U.S. Fish and Wildlife Service, Midway Atoll NWR, 1082 Makepono St., Honolulu, HI USA 96819

<sup>3</sup>U.S. Fish and Wildlife Service, Marine National Monuments of the Pacific, 300 Ala Moana Blvd. Suite 5-231, Honolulu, HI 96850

<sup>4</sup>U.S. Geological Survey, Colorado Cooperative Fish and Wildlife Research Unit, Colorado State University, 1484 Campus Delivery, Fort Collins, CO, 80523-1484

<sup>5</sup>U.S. Fish and Wildlife Service - Pacific Region, Migratory Birds and Habitat Program, 911 NE 11th Ave., Portland, OR 97232-4181

Population studies of albatross on Midway began nearly a century ago with the Tanager Expedition of 1923. Currently, studies continue following standardized protocols for conducting an annual census of nesting pairs and for monitoring survivorship and reproductive success. Numbers of nesting Laysan albatross (*Phoebastria immutabilis*) have increased in recent years, and black-footed albatross (*P. nigripes*) numbers have also shown a slight, increasing trend since atoll-wide censuses began in 1992. Preliminary results, however, suggest declines in reproductive success for both species since 2006. Recent advances in monitoring methodology and data management have improved data quality for future analyses. Additional information on longevity, philopatry, mate fidelity, and other life history traits are also provided from opportunistic resightings of the >270,000 Laysan and black-footed albatross banded at Midway since 1936. Individuals >50 years old of both species have been observed nesting on Midway in the past two years, as have several birds originally banded at other breeding sites in the Hawaiian Islands and the Mukojima Islands. In November 2018, a short-tailed

albatross (*P. albatrus*) pair that first appeared together in 2016 produced the first egg at Midway since 2013 and the first ever confirmed on Sand Island. USFWS staff, interns, volunteers, and contractors work together to document and quantify the effects of threats such as nest loss to inundation, ingestion of plastics and other contaminants, disease, and fishery bycatch; and address some of them with management and restoration of nesting habitat, control of predatory mice, removal of lead paint, and reduction of collision hazards.

#### MIGRATION ROUTES AND STOPOVER AREAS OF LEACH'S STORM PETRELS *OCEANODROMA LEUCORHOA*

Ingrid L. Pollet (ipollet@yahoo.com)<sup>1,2</sup>, Robert A. Ronconi (robert.ronconi@canada.ca)<sup>3</sup>, Marty L. Leonard (mleonard@dal.ca)<sup>3</sup>, Dave Shutler (dave.shutler@acadiau.ca)<sup>1\*</sup>

<sup>1</sup>Department of Biology, Acadia University, Wolfville, NS B4P 2R6, Canada

<sup>2</sup>Department of Biology, Dalhousie University, Halifax, NS B3H 4R2, Canada

<sup>3</sup>Environment Canada, Canadian Wildlife Service, 45 Alderney Dr., Dartmouth, NS B2Y 2N6, Canada

Information about movements of seabirds during migration is important for their conservation, but we are only now obtaining these data for birds weighing < 50 g. Leach's storm-petrel *Oceanodroma leucorhoa* is the most abundant seabird in Atlantic Canada, but its numbers have declined in recent years. Here, we describe trans-equatorial and trans-Atlantic migration movements of 13 Leach's storm-petrels from two breeding colonies in Nova Scotia, Canada, tracked with geolocators. Leach's storm-petrels had low migratory connectivity and they used multiple stopover areas and overwintering destinations. Birds with stopover areas at higher latitudes overwintered in the North Atlantic Ocean, either in areas associated with the North Equatorial Current or in waters off Newfoundland and Labrador. Birds with lower latitude stopover areas overwintered in the South Atlantic Ocean, in areas associated with the Benguela Current off southwestern Africa. We observed greater  $\delta^{15}\text{N}$  values (indicating higher trophic levels) in feathers from birds that migrated south compared to birds that stayed in the Northern Hemisphere, but we observed no difference in  $\delta^{13}\text{C}$  (which may be interpreted in multiple ways). High sea surface temperatures and high chlorophyll a concentrations

were important predictors of habitat use in winter. We have thus identified important habitats for these birds outside the breeding season.

#### A SEASON OF 'MURRE-TH': INCREASED REPRODUCTION OF COMMON MURRES (*URIA AALGE*) AT YAQUINA HEAD COLONY, OREGON, USA, FOLLOWING CONSECUTIVE FAILED BREEDING YEARS.

Jessica Porquez<sup>1</sup> [porquezj@oregonstate.edu](mailto:porquezj@oregonstate.edu) (presenting author)

Jane Dolliver<sup>2</sup> [jane.Dolliver@oregonstate.edu](mailto:jane.Dolliver@oregonstate.edu)

Rachael Orben<sup>1</sup> [Rachael.Orben@oregonstate.edu](mailto:Rachael.Orben@oregonstate.edu)

Don Lyons<sup>2</sup> [Don.Lyons@oregonstate.edu](mailto:Don.Lyons@oregonstate.edu)

Rob Suryan<sup>3</sup> [rob.suryan@noaa.gov](mailto:rob.suryan@noaa.gov)

<sup>1</sup>Department of Fisheries & Wildlife, Oregon State University, Hatfield Marine Science Center, 2030 SE Marine Science Drive, Newport, OR, USA 97365

<sup>2</sup>Department of Fisheries & Wildlife, Oregon State University, 2820 SW Campus Way, Corvallis, OR, USA 97331

<sup>3</sup>NOAA Fisheries, Alaska Fisheries Science Center, Auke Bay Laboratories, 17109 Pt. Lena Loop Rd, Juneau, AK, USA 99801

Since 2010, reproductive success of common murres (*Uria aalge*) has steadily declined at the Yaquina Head Outstanding Natural Area in Newport, Oregon. From 2014-2017, near or total breeding failures were related to increased predation and unfavorable foraging conditions (e.g. a positive Pacific Decadal Oscillation, PDO, the 'Warm Blob' and El Niño). The 2018 breeding season, however, coincided with a sustained shift toward a cooler, negative PDO and we observed the highest hatching (0.51, se  $\pm$  0.04) and reproductive (0.79, se  $\pm$  0.04) success rates at the site in 8 and 10 years, respectively. Smelts (*Osmeridae*) continued to be a dominant prey species provisioned to chicks. Murre egg (0.77/hr, se  $\pm$  0.02) and adult (0.15/hr, se  $\pm$  0.01) predation rates were both lower than in previous years although there was an increase in unique events (120 total), indicating greater resilience of nesting murres to disturbances in 2018 than in recent years. Chick predation in 2018 (0.04/hr, se  $\pm$  0.008) was consistent with previous years (barring a devastating event in 2012). Improved foraging conditions in 2018 appeared to support greater resilience to predators for nesting murres. Unfortunately, improved breeding success at Yaquina Head may be short-lived, as a second warming event intensifies in the North Pacific, possibly migrating to the Oregon coast in 2019.

## SEABIRD RESPONSE TO AN ON-GOING RAT ERADICATION PROJECT ON LEHUA ISLET, KAUA'I.

Raine, A.F.<sup>1</sup> (araine6@hawaii.edu), VanderWerf, E.<sup>5</sup> (eric@pacificrimconservation.org), Atwood, J.P.<sup>2</sup> (Joshua.P.Atwood@hawaii.gov), Chee, P.C.<sup>2</sup> (patrick.c.chee@hawaii.gov), Chow, C.K.<sup>2</sup> (clay.k.chow@hawaii.gov), Baiao, P.<sup>3</sup> (patty.baiao@islandconservation.org), Khalsa, M.<sup>3</sup> (mele.khalsa@islandconservation.org), Howald, G.<sup>3</sup> (gregg.howald@islandconservation.org), S.R. Siers<sup>4</sup> (Shane.R.Siers@aphis.usda.gov) & Mann, S.S.<sup>2</sup> (Sheri.S.Mann@hawaii.gov)

<sup>1</sup> Kauai Endangered Seabird Recovery Project, 3900 Hanapepe Rd, Hanapepe, Kauai, HI 96716

<sup>2</sup> Department of Land & Natural Resources, Division of Forestry & Wildlife, 3060 Eiwa St # 306, Lihue, HI 96766 or Kalanimoku Building 1151 Punchbowl St. Room 325 Honolulu, HI 96813

<sup>3</sup> Island Conservation, 2100 Delaware Ave., Suite 1 Santa Cruz, CA 95060 U.S.A.

<sup>4</sup> USDA APHIS Wildlife Services National Wildlife Research Center, Hawaii Field Station, Hilo, HI

<sup>5</sup> Pacific Rim Conservation, PO Box 61827, Honolulu, Hawaii 96839

Lehua Islet is a Bird Sanctuary situated 19 miles off the coast of Kaua'i. Considered the most important seabird islet in the main Hawaiian Islands, Lehua has nine confirmed breeding seabird species including the only U.S. breeding population of Black-footed Albatross *Phoebastria nigripes* outside of the north-western Hawaiian Islands and a breeding population of the endangered Band-rumped Storm-petrel *Oceanodroma castro*. However, seabirds on the islet have been heavily impacted by the introduced Polynesian Rat *Rattus exulans*, which have also prevented native plant restoration efforts. In 2017 an ambitious multi-partner project was initiated to eradicate rats off Lehua, using aerial drops of Diphacinone. To assess the impact of this island restoration effort, we present data on rat prevalence and seabird response by the end of 2018 using multiple techniques including burrow cameras, seabird plots, burrow monitoring and acoustic recording devices. Remote cameras indicate that a small number of rats are still present indicating that total eradication may not have been achieved. Despite this, the rat population has been dramatically suppressed and seabird response to this is considered in terms of estimated population sizes, reproductive

success rates and breeding distribution for multiple species. In particular, the smaller seabird species appear to have benefited the most from the eradication effort, with the number of breeding Bulwer's Petrel *Bulweria bulwerii* burrows and their respective reproductive success being significantly higher in 2018 than previously. With these results in mind, we discuss possible directions for the Lehua Islet Restoration Project in 2019 and beyond.

## SHIFTS IN STABLE ISOTOPE VALUES OF STORM PETREL FEATHERS FROM 1880S TO TODAY

Lyndsay Rankin (lrankin@niu.edu)<sup>1</sup>, Holly Jones (hjones@niu.edu)<sup>1</sup>, Michael Wunder (michael.wunder@ucdenver.edu)<sup>2</sup>, Matt Rayner (mrayner@aucklandmuseum.com)<sup>3</sup>

<sup>1</sup>Northern Illinois University, 1425 W. Lincoln Hwy, DeKalb, IL 60115

<sup>2</sup>University of Colorado Denver, 1201 Larimer St, Denver, CO 80204

<sup>3</sup>Auckland War Memorial Museum, The Domain, Victoria Street West, Auckland 1142, New Zealand

Stable isotope analysis (SIA) is often used to infer animal foraging location, prey sources, and ecological changes. In seabird ecology, SIA of historic and contemporary samples has provided information on shifts in prey trophic position and foraging preferences in response to changing ocean conditions. As pelagic feeders with extensive ranges, Procellariiformes are heavily impacted by ocean conditions such as fisheries and climate change. Expansive industrial fishing has resulted in prey trophic shifts over time as species either avoid fishing vessels or are attracted to discards. These studies have focused on larger, mostly fish-consuming Procellariiformes, with little research on foraging changes of the smaller, crustacean-consuming seabirds. We collected white-faced storm petrel (*Pelagodroma marina*) feathers from 5 museums, spanning 130 years. Carbon isotope values ( $\delta^{13}\text{C}$ ) were analyzed for potential shifts in foraging locations and nitrogen values ( $\delta^{15}\text{N}$ ) were used to determine prey trophic level changes. Steadily decreasing carbon values are consistent with changing oceanic carbon values. Prior to 1950, nitrogen values exhibited little variability. Variance in  $\delta^{15}\text{N}$  increased greatly following 1950, around the time of industrial fishing expansion. Between 1950 and 1980, higher  $\delta^{15}\text{N}$  values indicate a shift to higher trophic level prey. After 1980,  $\delta^{15}\text{N}$  values were lower on average than before 1950. These

trophic level shifts in storm petrel diet could indicate that industrial fishing or other human-related activities have the potential to impact even the smallest Procellariiformes.

#### THE LEGACY OF THE PACIFIC PROJECT: THE SECRET BIO-WEAPONS TESTING PROGRAM AND THE ROLE SEABIRDS PLAYED IN IT

Mark J. Rauzon ([mrauzon@peralta.edu](mailto:mrauzon@peralta.edu))  
Laney College, Geography Department, 900 Fallon  
Street, Oakland, CA 94704

The Pacific Project began in 1962 under the Kennedy Administration as a broad-based program to determine the effects of a biological and chemical weapon attack. The Pacific Project was managed by the U. S. Army who contracted with the Smithsonian Institution to conduct surveys over vast ocean areas. The resultant Pacific Ocean Biological Survey Program (POBSP) sent ~70 scientists to remote islands in the Pacific Ocean to inventory flora and fauna, band birds, collect blood samples and to conduct at-sea surveys. Live birds were also sent to Fort Detrick, MD. to be challenged with disease. The data was used to determine where seabirds would be less likely to spread Tularemia and Q fever that was being tested on and around ships. Insights obtained by the Freedom of Information Act prove sailors were exposed to harsh chemicals and biological agents, and incipient radiation for the ships that were previously used in atomic testing. In Ship Hazard and Defense (aka SHAD), ships would be sprayed with benign chemicals and bacteria simulating a real attack, and how a ship might be affected. Lethal germs were sprayed on barges towed by the ships that carried monkeys. The SHAD veteran's long-term illnesses and premature deaths have not been recognized nor compensated for by the Veteran's Administration, while many POSPB biologists become leading marine researchers and program administrators.

#### MOONLIGHT AFFECTS COLONY ATTENDANCE AND NOCTURNAL FORAGING BEHAVIOR OF THE WEDGE-TAILED SHEARWATER (*ARDENNA PACIFICA*)

Andreas Ravache<sup>1,2</sup> ([andreas.ravache@ird.fr](mailto:andreas.ravache@ird.fr)), Karen Bourgeois ([karen.bourgeois2@gmail.com](mailto:karen.bourgeois2@gmail.com)), Sylvain Dromzée ([amorifantelis@gmail.com](mailto:amorifantelis@gmail.com)), Henri Weimerskirch<sup>3</sup> ([Henri.WEIMERSKIRCH@cebc.cnrs.fr](mailto:Henri.WEIMERSKIRCH@cebc.cnrs.fr)), Sophie de Grissac<sup>3</sup> ([s.degrissac@gmail.com](mailto:s.degrissac@gmail.com)), Aurelien Prudor<sup>3</sup>

([prudor.aurelien@gmail.com](mailto:prudor.aurelien@gmail.com)), Yves Letourneur<sup>2</sup> ([yves.letourneur@univ-nc.nc](mailto:yves.letourneur@univ-nc.nc)), Eric Vidal<sup>1</sup> ([eric.vidal@ird.fr](mailto:eric.vidal@ird.fr))

<sup>1</sup>IMBE Aix-Marseille Université, CNRS, IRD, UAPV, Centre IRD Nouméa - BP A5, 98848 Nouméa Cedex, New-Caledonia

<sup>2</sup>University of New Caledonia / ISEA, New-Caledonia

<sup>3</sup>Centres d'Etudes Biologiques de Chizé – CNRS, France

Moon phase and illumination are known to affect nocturnal behavior of many organisms, particularly through predator-prey interactions. Visual predators can benefit from higher light levels to increase their activity, while preys may decrease it to avoid predation. Nocturnal seabirds can tune their foraging trip duration to attend colony under moonless conditions. This has been mostly perceived as a predation avoidance strategy. But this could also be related to a higher nocturnal foraging ability allowed by a higher moonlight intensity thus a greater visibility. Miniaturized GPS-loggers allowed us to obtain 180 tracks from 99 Wedge-tailed shearwaters breeding in New-Caledonia and to investigate moonlight effects on individual behavior. Moon phase significantly predicted self-feeding trip duration, when adults target more productive and distant areas. However, this relationship was not significant during chick-feeding trips when adults have to frequently return to the colony. Adults did not significantly return to the colony during moonless periods. Tracked individuals showed an unexpectedly high nocturnal foraging activity, which was positively correlated with moonlight. The individuals feeding mostly during the night performed longer trips, reached farther areas, and departed the colony under a higher moon illumination than the individuals feeding mostly during daylight. Stable isotope analyses revealed that adults fed on different prey when foraging during the day or at night whereas their foraging areas were similar. This study showed that lower colony attendance by wedge-tailed shearwaters during moonlit night might be rather linked to a higher foraging opportunity at sea than a higher predation risk on land.

#### TAHITI PETREL (*PSEUDOBULWERIA ROSTRATA*): TRYING TO LIFTING THE VEIL ON A MYSTERIOUS AND THREATENED PACIFIC SEABIRD

Andreas Ravache<sup>1,2</sup> ([andreas.ravache@ird.fr](mailto:andreas.ravache@ird.fr)), Angélique Pagenaud<sup>1,2</sup> ([angelique.pagenaud@ird.fr](mailto:angelique.pagenaud@ird.fr)),



Karen Bourgeois<sup>1</sup> ([karen.bourgeois2@gmail.com](mailto:karen.bourgeois2@gmail.com)),  
Pauline Palmas<sup>1</sup> ([pauline.palmas@ird.fr](mailto:pauline.palmas@ird.fr)), Sylvain  
Dromzée<sup>1</sup> ([amorifantelis@gmail.com](mailto:amorifantelis@gmail.com)), Éric Vidal<sup>1</sup>  
([eric.vidal@ird.fr](mailto:eric.vidal@ird.fr)).

<sup>1</sup>IMBE Aix-Marseille Université, CNRS, IRD, UAPV,  
Centre IRD Nouméa - BP A5, 98848 Nouméa Cedex,  
New-Caledonia

<sup>2</sup>University of New Caledonia/ISEA, New-Caledonia

Seabirds are among the most threatened vertebrate taxa and among them, the *Pseudobulweria* genus is one of the least known and most threatened, with one species already extinct and three out of four species critically endangered. The Tahiti petrel (*P. rostrata*) is the only *Pseudobulweria* species currently listed in the Near Threatened IUCN category. However, in reality little is known about its biology and ecology, both on land and at sea, making particularly questionable the assessment of its true conservation status along with the implementation of effective conservation strategies. In New Caledonia, a major research effort is currently dedicated to this species, combining (i) at-sea tracking both during the breeding and inter-breeding periods, (ii) colony survey and breeding cycle monitoring (2 study sites), (iii) evaluation of feral cats predation on Tahiti petrels (6 study sites), along with the assessment of mining activities. Indeed, (i) GPS and GLS tracking allow us to determine important marine areas for this species, where individuals may be exposed to bycatch and competition with fisheries; (ii) land based monitoring helps to shed the light on the reproduction phenology, rate of activity and demographic parameters of the Tahiti petrel; (iii) feral cat predation rates highlights a high threat of this invasive predator for this seabird species. Moreover, some investigations about burrows and breeding habitat characteristics will help to design artificial burrows and to identify possible translocation areas. Finally, these unprecedented results will make it possible to reassess its conservation status, and to restore and conserve this elusive species through action plans on land and at sea.

## ALEUTIAN TERN SURVEYS ON SAKHALIN ISLAND, RUSSIA

Heather M. Renner ([heather\\_renner@fws.gov](mailto:heather_renner@fws.gov))<sup>1</sup>,  
Donald E. Lyons<sup>2</sup>, Martin Renner<sup>3</sup>

<sup>1</sup>USFWS Alaska Maritime National Wildlife Refuge, 95  
Sterling HWY, Suite 1, Homer AK 99603,

<sup>2</sup>National Audubon Society Seabird Restoration  
Program, 104 Nash Hall, Corvallis OR 97331

<sup>3</sup>Tern Again Consulting, 811 Ocean Drive Loop, Homer  
AK 99603

Steep declines of Aleutian terns (*Onychoprion aleuticus*) at known colonies across Alaska in recent decades have contrasted with reports from Russian colonies of stable or increasing trends. During June 2018, we visited three major island colonies on the northeast coast of Sakhalin Island, Russia, and conducted surveys with Russian experts. We assessed colony size using counts of flushed individuals, the size and density of nesting areas, and aerial imagery obtained using an unmanned aerial vehicle. Both Aleutian and common terns (*Sterna hirundo*) were present at all colonies surveyed, so we also estimated species ratios by counting individuals of each species in the air. For each of the three colonies, we estimated that the numbers of Aleutian terns present and nesting during our visit were less than reported for the years 2011–2012, although colonies were of significant size relative to colonies in Alaska. Analyses of aerial imagery to confirm and refine this result is ongoing. In at least one instance, we observed numbers more than an order of magnitude lower than reported previously. We consider it unlikely, that this was due to a long-term demographic decline, but more likely due to short term factors. These could include unusually cold water temperatures in early June, disturbance by bears, or discrepancies in methods. Short-term and long-term actions have been identified to maintain engagement between Russian and American experts and to improve population assessments across the entire species range.

## UNMANNED AIRCRAFT SYSTEMS AND SEABIRD INTERACTIONS

Karen Reyna ([Karen.reyna@noaa.gov](mailto:Karen.reyna@noaa.gov))<sup>1</sup>

<sup>1</sup>Greater Farallones National Marine Sanctuary, 991  
Marine Dr., San Francisco, CA 94129

Unmanned Aircraft Systems (UAS) have become increasingly prevalent in the last decade. Despite this rapid growth, there have been a limited number of studies examining the effects of UAS operations on seabirds, particularly when flown at lower altitudes. Nevertheless, there is enough information related to observed wildlife reactions that can help us draw recommendations to promote responsible UAS use for both recreational users and researchers. This presentation will highlight how West Coast National Marine Sanctuaries have learned about frequently

used UAS flown in close proximity to wildlife and used that information to minimize wildlife disturbance. We will discuss recommendations related to permit conditions for UAS low overflight research permits. We will showcase examples of effective ways to work with UAS hobbyists. We will highlight studies regarding behavioral impacts to date and offer several recommendations for ways to minimize the impacts of UAS usage on seabirds and marine mammals.

#### MICROPLASTIC INGESTION BY PACIFIC SAND LANCE (*AMMODYTES PERSONATUS*) IN AN IMPORTANT BIRD AREA AND MIGRATORY BIRD SANCTUARY IN THE SOUTHERN SALISH SEA

Robinson, C.L.K, ([Cliff.Robinson@dfo-mpo.gc.ca](mailto:Cliff.Robinson@dfo-mpo.gc.ca))<sup>1</sup>, Bertram D.F. ([Douglas.bertram@dfo-mpo.gc.ca](mailto:Douglas.bertram@dfo-mpo.gc.ca))<sup>2</sup>, M. Sizer<sup>3</sup>, M. Hennekes<sup>3</sup>, M. Galbraith<sup>3</sup>, S. Gauthier<sup>3</sup>, K. Woo<sup>4</sup> and P.S. Ross<sup>5</sup>

<sup>1</sup>DFO, Pacific Biological Station, Nanaimo, BC, V9T 6N7  
<sup>2</sup>ECCC, Institute of Ocean Sciences, Sidney, BC, V8L 4B2

<sup>3</sup>DFO, Institute of Ocean Sciences, Sidney, BC, V8L 4B2  
<sup>4</sup>ECCC, Pacific Wildlife Research Centre, Delta, BC, V4K 3N2

<sup>5</sup>CORI, West Vancouver Laboratory

We report on microplastic concentrations in the guts of Pacific Sand Lance (*Ammodytes personatus*) which were captured in Sidney Channel Important Bird Area (IBA, 2013-2017), and more recently, Victoria Harbour Migratory Bird Sanctuary (2017) within the Salish Sea, Canada. We collected fish (n= 201) which were buried in the subtidal habitats using a van Veen grab. Suspected microplastic fibres were consistently found in over 70 % of Pacific Sand Lance stomachs and individual fish with suspected plastics had between 1 and 63 pieces in their gut. Coloured fibres (black, blue, clear, green, red, orange, yellow) averaged 2.8 mm and a subsample were analyzed for chemical composition determination using FTIR microscopy. The samples contained fibres of plastics (polyester, acrylic, nylon, polypropylene), cotton; rayon, cellulose, regenerated cellulose and modified cellulose, silk, ribbon rubber, mineral and clay. At-sea densities of Rhinoceros Auklet are high in our study area during the breeding season and microplastic fibres have independently been found in sand lance collected in nestling diets on Protection Island, a large colony in nearby Washington State. Many other fish eating birds are seasonally abundant and in our study region. Wastewater outfalls in the Sidney Channel IBA and in the Victoria Harbour

Migratory Bird Sanctuary could be contributing sources of microplastics in the local food web.

#### IMPACTS OF THE DECEMBER 2016 TO AUGUST 2017 BOGOSLOF ISLAND ERUPTION EVENT ON A MAJOR ALASKAN SEABIRD COLONY

Nora A. Rojek ([nora\\_rojek@fws.gov](mailto:nora_rojek@fws.gov))<sup>1</sup> and Gary S. Drew ([gdrew@usgs.gov](mailto:gdrew@usgs.gov))<sup>2</sup>

<sup>1</sup>USFWS Alaska Maritime National Wildlife Refuge, 95 Sterling HWY, Suite 1, Homer AK 99603

<sup>2</sup>USGS Alaska Science Center, 4200 University Dr., Anchorage AK 99508

Bogoslof Island, managed by the Alaska Maritime National Wildlife Refuge, is an important breeding site for seabirds and marine mammals in the southeastern Bering Sea. Importantly, it includes one of only four major breeding sites for red-legged kittiwakes (*Rissa brevirostris*). Periodic eruptions of Bogoslof volcano result in a changing landscape and alters seabird nesting habitat. The most recent event of at least 64 eruptions over eight months increased island area by 300% and buried vegetation and soil. Continuous eruptive activity in summer 2017 likely prevented seabirds from successfully breeding that season. In August 2018, a site visit detected the presence of most seabird species known to previously occupy the island but with little evidence of successful breeding except by glaucous-winged gulls (*Larus glaucescens*). Species that build nests, such as kittiwakes (*Rissa* spp.) and cormorants (*Phalacrocorax* spp.), lost access to nest materials. The main pre-eruption breeding area for murrelets (*Uria* spp.) was altered and unoccupied and only a small number of eggs and chicks were observed. Tufted puffins (*Fratercula cirrhata*), which typically rely on soil and vegetation for burrows, lost all nesting habitat; birds attempted to dig new burrows but could not excavate far into hard surface layers and unconsolidated subsurface layers. Because most long-lived seabirds exhibit colony site fidelity, we expected them to return with limited impact on population numbers. However, given that no fine ash was deposited during the eruptions, soil development is expected to be prolonged. Species relying on vegetation for nests and soil for burrows may be constrained from breeding until soil develops.

WHAT'S GOING ON WITH SEABIRDS IN THE  
PRIBILOFS?: PUTTING RECENT POOR BREEDING  
PERFORMANCE INTO A BROADER TEMPORAL AND  
SPATIAL PERSPECTIVE

Marc D. Romano<sup>1,2</sup>, Aaron M. Christ, Donald E. Dragoo,  
Heather M. Renner<sup>1</sup>

<sup>1</sup>Alaska Maritime National Wildlife Refuge, 95 Sterling  
Highway, Suite 1, Homer, AK 99603

<sup>2</sup> [marc\\_romano@fws.gov](mailto:marc_romano@fws.gov)

The seabird colonies at St. Paul and St. George islands, Pribilof Islands, Alaska have been monitored by the U.S. Fish and Wildlife Service and its partners for 43 years. Data have been collected on breeding chronology, reproductive success, and colony attendance of murre (*Uria spp.*) and kittiwakes (*Rissa spp.*). These species have experienced poor breeding performance during one or more years since 2015. This coincides with several years of anomalously warm water temperatures in the Bering Sea, and several seabird die-offs in the region. Against this backdrop, we described long term patterns and variability in reproductive performance and evaluated the relative frequency of complete, or near complete, reproductive failures to determine if these failures are within normal variability or are unprecedented events. From 2015-18 both kittiwake species suffered near complete reproductive failure (productivity  $\leq 5\%$ ) on both islands. Murre reproductive success was significantly below the long-term mean (50%) on St. Paul for both species in 2016 and 2017, and near complete failure (reproductive success  $\leq 5\%$ ) of both murre species, at both islands, occurred in 2016. Kittiwakes have experienced multiple concurrent years of reproductive failure in the past, especially in the early 1980s (1982-85), which preceded a population decline. In contrast, murre reproductive success for both species and islands combined had not been observed below 24% prior to 2016, and the near complete breeding failure experienced in 2016 was unprecedented for the Pribilofs. Data gathered from multiple seabird colonies throughout the Bering and Chukchi seas in 2018 suggests that poor seabird breeding performance in the Pribilof Islands might be part of a larger, regionwide signal.

TROPHIC ECOLOGY OF TWO SYMPATRIC  
ENDANGERED SEABIRDS: THE HEERMANN'S GULL  
*LARUS HEERMANNI* AND THE ELEGANT TERN  
*THALASSEUS ELEGANS* IN THE GULF OF CALIFORNIA

Rigoberto Rosas-Luis ([riroluis@yahoo.com.mx](mailto:riroluis@yahoo.com.mx)),  
Enriqueta Velarde<sup>2</sup>  
([enriqueta\\_velarde@yahoo.com.mx](mailto:enriqueta_velarde@yahoo.com.mx)), Joan Navarro<sup>3</sup>  
([joan@icm.csic.es](mailto:joan@icm.csic.es))

<sup>1</sup>CONACYT-Tecnológico Nacional de México, Instituto  
Tecnológico de Chetumal. Av. Insurgentes No. 330,  
Col. David Gustavo Gutiérrez., 77013 Chetumal,  
Quintana Roo, Mexico.

<sup>2</sup>Instituto de Ciencias Marinas y Pesquerías,  
Universidad Veracruzana, Hidalgo 617, Col. Río  
Jamapa, Boca del Río, Veracruz, CP 94290, Mexico.

<sup>3</sup>Instituto de Ciencias del Mar CSIC, Barcelona 08003,  
Spain.

Development and good state of seabird populations depend on factors such as climate conditions, food availability, and habitat structure. In the Gulf of California, Isla Rasa is the main breeding area for *T. elegans* and *L. heermanni*, and the availability of small pelagic fishes seems to be the main factor that determines their breeding success. Due to the importance of small pelagic fishes for seabirds, in this work we analyzed the  $\delta^{13}\text{C}$  and  $\delta^{15}\text{N}$  isotopic composition of chick down of both seabird species, and compared with prey regurgitated by adults during the breeding season 2017. Results showed that small pelagic fishes were the main prey caught by adults and that *E. mordax*, *S. sagax*, and *S. japonicus* were the most important contributors of  $\delta^{13}\text{C}$  and  $\delta^{15}\text{N}$  in the chick down. *T. elegans* can be catalogued as a specialist predator with a narrower trophic niche than *L. heermanni*. Both species used small pelagic fishes as prey during the breeding season, but *L. heermanni* included other feeding sources, promoting a segregation of the foraging area and reduced competition between both species. The strong trophic relationship found between small pelagic fishes and seabirds enforces the convenience of the creation of areas of fishing exclusion in the central Gulf of California, which would favor the nesting success of these species during the breeding season.

## QUANTIFYING PATTERNS OF INTRASPECIFIC FORAGING VARIATION IN PELAGIC SEABIRDS PAST AND PRESENT

Sam Rossman (srossman@hswri.org)<sup>1</sup>, Anne E. Wiley (awiley@uakron.edu)<sup>2</sup>, Peggy H. Ostrom (ostrom@msu.edu)<sup>3</sup>, and Helen F. James (jamesh@si.edu)<sup>4</sup>

<sup>1</sup>Hubbs-SeaWorld Research Institute, 3830 S. Highway A1A #4-181, Melbourne Beach, Florida 32951, USA

<sup>2</sup>Department of Biology, University of Akron, Auburn Science Center, 235 Carroll Street, Suite D401, Akron, Ohio 44325, USA

<sup>3</sup>Department of Integrative Biology, Michigan State University, 203 Natural Science Building, 288 Farm Lane, East Lansing, Michigan 48824, USA

<sup>4</sup>Department of Vertebrate Zoology, National Museum of Natural History, Smithsonian Institution, P.O. Box 37012, 10<sup>th</sup> Street and Constitution Avenue NW, Washington, D.C. 20560, USA

Conspecifics within a population are not ecologically equivalent; individuals often use a subset of population-level resources thus demonstrating “individual specialization”. Maintaining this ecological diversity is critically important to conservation planning as it promotes resilience to disturbance and provides variation natural selection can act upon. However, documenting historical measures of individual specialization, by which to compare current values, is extremely difficult as most common approaches (*i.e.* regurgitation) are unavailable for historical studies. We present a new method suitable for modern and museum specimens which quantifies individual specialization using stable isotope analysis on sequentially grown flight feathers. By repeatedly sampling feathers we parameterize a normal distribution with mean and standard deviation for every individual. We then hierarchically specify that each individual mean is observed from a mean population-level normal distribution. We ground this model in a case study of the endangered Hawaiian petrel (*Pterodroma sandwichensis*). We compared the degree of individual specialization between nesting populations in Lānaʻi and Haleakalā, Maui. We found that while the two colonies used very different non-breeding season foraging locations, they both demonstrate a high degree of individual generalization where individuals use a large portion of the population-level resources. We further demonstrate the utility of this approach to historical ecology by comparing our measures of individual specialization to those obtained from museum specimens to test if

the dramatic reduction in breeding colonies was concurrent with a loss in ecological diversity.

## ACOUSTIC DETECTIONS OF ASHY STORM-PETREL ON SAN NICOLAS ISLAND, CALIFORNIA

Martin Ruane (martin.ruane@navy.mil)<sup>1</sup>, William Hoyer (william.hoyer@navy.mil)<sup>1</sup>, Josh Adams (josh\_adams@usgs.gov)<sup>2</sup>, Emily Kelsey (ekelsey@usgs.gov)<sup>2</sup>, Matthew McKown (matthew.mckown@conservationmetrics.com)<sup>3</sup>, Paige Roberts (paige@conservationmetrics.com)<sup>3</sup>, and Kathryn Norris (kathryn.norris@tetratech.com)<sup>4</sup>

<sup>1</sup>Naval Base Ventura County, 311 Main Rd. Point Mugu, CA USA 93042 \*presenter

<sup>2</sup>WERC Santa Cruz Field Station, 2885 Mission St. Santa Cruz, CA 95060

<sup>3</sup>Conservation Metrics Inc., 145 McAllister Way, Santa Cruz, CA 95060

<sup>4</sup>Tetra Tech Inc., 825 West Custer Avenue, Helena, MT 50602

Acoustic recording units (ARUs) can help identify presence and relative abundance of rare or cryptic species in remote habitats that present logistical challenges. Little effort has been applied to survey Naval Base Ventura County San Nicolas Island (SNI) for Ashy Storm-Petrel (*Oceanodroma homochroa*, ASSP). Previous biologists suggested SNI lacks suitable nesting habitat for storm-petrels, and none likely nest there (Hunt et al. 1979, Carter et al. 1992). In 2016, during an effort to document Scripps’s Murrelet (*Synthlyboramphus scrippsi*), researchers deployed three ARUs opportunistically in “potential storm-petrel habitat”. Recordings from all sites contained ASSP aerial calls. A single ASSP “purr” call (typically made on the ground or inside a burrow) was also detected. Based on 2016 results, in 2017 we deployed 10 ARUs in similar habitat; aerial calls were detected at 9 sites and ground calls detected at one site. Few sites had regular vocalizations during 3 to 4 months of the known ASSP breeding season, while other sites had few calls. To follow up in 2018, we deployed 11 ARUs and habitats were again evaluated at ARU and additional sites. We found limited crevice, rock pile, and lithified sandstone habitat, but no nesting storm-petrels. Although much habitat may be accessible to island foxes (*Urocyon littoralis dickeyi*), repeated, adaptive deployments of ARUs has confirmed Grinnell’s (1897) observations that storm-petrels visit SNI, and that at some sites, ASSP vocalizations persist throughout the breeding season. Furthermore,

acoustic survey techniques have provided a baseline and focus for additional survey activities including mist-netting and additional nest searching in potential storm-petrel habitat on SNI.

#### USING UNMANNED AIRCRAFT SYSTEMS FOR MONITORING CALIFORNIA LEAST TERN NESTING COLONIES AT NAVAL BASE VENTURA COUNTY

Martin Ruane (martin.ruane@navy.mil)<sup>1</sup>, Dr. Jean Pan (jean.pan@navy.mil)<sup>2</sup>, and Alan Jaeger (AJaeger@vcoe.org)<sup>3</sup>

<sup>1</sup>Naval Base Ventura County, 311 Main Rd. Point Mugu, CA USA 93042 \*presenter

<sup>2</sup>NAVFAC Engineering and Expeditionary Warfare Center, 1000 23<sup>rd</sup> Ave., Port Hueneme, CA USA 93043

<sup>3</sup>Naval Sea Systems, Port Hueneme Division, Port Hueneme, CA USA 93043

Naval Base Ventura County conducts field monitoring of the endangered California least terns (*Sterna antillarum browni*) to assess nesting colony size and hatching success. Field surveys consist of biologists walking through the nesting colonies and collecting data 2-3 times per week. To reduce disturbance to chicks, field crews discontinue walking through the colony after the first chicks begin to hatch. Only a small subset of the nests that are visible from blinds or roads can then be tracked, leading to a data gap between the egg incubation stage and hatching for a majority of nests.

To address this data gap, we investigated the use of unmanned aircraft systems (UAS) to collect data from the air on incubation status of least tern nests. Our objectives were to determine whether: 1) UAS would disturb incubating terns, 2) eggs, chicks, fledglings, and adults could be identified from UAS imagery, and 3) UAS data can be used to address the current data gap and provide additional data on fledgling success. During this project various UASs, flight speeds and elevations, software programs, and sensors were used to determine the best platform to capture data.

We found that terns were not disturbed, with adults continuing to incubate when the UAS was overhead. We were able to identify from imagery different life stages of least terns, with adults incubating eggs and/or brooding chicks easiest to identify, followed by fledglings, then eggs, and lastly chicks. By incorporating geospatial information from ground surveys, it was possible to track nest status. Results

from this study indicate UAS can contribute to filling the current data gap and may provide additional fledgling data for monitoring least terns at NBVC Point Mugu.

#### PROTECTING BIRDS AND PILOTS: LAYSAN ALBATROSS MANAGEMENT ON A NAVY INSTALLATION

Katherine Rubiano (krubiano@hawaii.edu)<sup>1</sup>, Rachel Herring (NAVFAC HI), Brooke McFarland

<sup>1</sup>Katherine Rubiano, United States Navy, United States Department of Agriculture Wildlife Services, Naval Facilities Engineering Command Hawai'i, Pacific Missile Range Facility, PO Box 128, PMRF Air Operations Bldg. 384, Kekaha, HI 96752

The Pacific Missile Range Facility (PMRF) Bird Aircraft Strike Hazard (BASH) Program is a Department of the Navy program administered by the United States Department of Agriculture Wildlife Services (USDA-WS) with support from the PMRF Natural Resources Program. An important aspect of this program involves the reduction in strike risks posed by a Laysan Albatross breeding colony within the PMRF airfield and surrounding areas. These efforts strive to reduce the population utilizing the site while bolstering populations of Laysan Albatross far from the PMRF airfield. This talk will detail Laysan Albatross management practices at PMRF, the collaborative PMRF Albatross Egg Swap program, and preliminary findings from observational data collected over the years.

#### MALE STREAKED SHEARWATERS (*CALONECTRIS LEUCOMELAS*) ADJUSTED THEIR TRIP DURATIONS BASED ON PRESENCE OR ABSENCE OF PAIRED FEMALES.

Miho Sakao (sakao-m@aori.u-tokyo.ac.jp)<sup>1</sup>, Yusuke Goto ([goto924@gmail.com](mailto:goto924@gmail.com)), Akinori Takahashi(atak@nipr.ac.jp)<sup>2</sup>, Katsufumi Sato(katsu@aori.u-tokyo.ac.jp)<sup>1</sup>

<sup>1</sup>The Atmosphere and Ocean Research Institute, The University of Tokyo, 5-1-5 Kashiwa-no-ha, Kashiwa-city, Chiba, 277-8564, Japan

<sup>2</sup>National Institute of Polar Research 10-3 Midori-cho, Tachikawa-shi, Tokyo, 190-8518, Japan

The optimal allocation of time between one's own survival and current breeding is critical for iteroparous animals such as seabirds. In breeding period, males and females are expected to allocate their time to self-conditioning behavior and breeding behavior such as mate and nest guarding, mating, and provisioning for their chick. For central-place foragers, foraging trip durations may reflect this allocation. In the mating period, seabirds are central-place foragers and they need to allocate their time to mate at the colony and to forage at sea. However, few studies investigated how seabirds manage their time during the mating period. Especially, among streaked shearwaters (*Calonectris leucomelas*), extra-pair paternity frequently occurs. Therefore, time allocation for mating or foraging should have significant ecological implications for them. In this study, we examined male's and female's allocation of their time during mating period using geolocators in streaked shearwaters. We found that 64.1 % of male shearwater's foraging trip was one-day trip and they foraged at close area to the colony. We also found that males extended their trip length after they met their partners at the nest. However, females took longer trips than males and went to the more distant and highly productive area of the sea. Females did not change their trip length regardless of the presence or absence of their partners. This suggests that male shearwaters adjust their trip length based on the presence or absence of paired female to control their time between mating and foraging and to secure their paternity.

#### INDIVIDUAL TRACKING INFORMS EXPOSURE OF THE ENDANGERED BLACK-CAPPED PETREL TO MARINE THREATS DURING THE BREEDING SEASON

Yvan G. Satgé (ysatge@g.clemson.edu)<sup>1</sup>, Ernst Rupp (ernst.rupp@grupojaragua.org.do)<sup>2</sup>, and Patrick G.R. Jodice (pjodice@g.clemson.edu)<sup>3</sup>

<sup>1</sup>South Carolina Cooperative Fish and Wildlife Research Unit, Clemson University, Clemson, SC USA 29634

<sup>2</sup>Grupo Jaragua, Santo Domingo, Dominican Republic

<sup>3</sup>U.S. Geological Survey South Carolina Cooperative Fish and Wildlife Research Unit, Clemson University, Clemson, SC USA 29634

The Diablotin Black-capped Petrel, (*Pterodroma hasitata*) is a gadfly petrel endemic to the Caribbean. The species has a fragmented and declining population, is considered Endangered throughout its

range and has recently been proposed for listing under the Endangered Species Act by the U.S. Fish and Wildlife Service. Interactions with anthropogenic activities at sea have been under-studied although they are likely to impact the survival of the species. During April 2018 we tracked three chick-rearing petrels nesting in the Dominican Republic using remote-download GPS technology. Tracked petrels travelled between 2,000 and 4,000 km and engaged in area-restricted search 34.5% of the time they were away from nest sites. While our results showed differences in individual choices of foraging areas they demonstrated regular use of the Caribbean basin but infrequent use of Gulf Stream associated waters. For two of the birds, foraging areas appeared to be associated with physical processes such as the Guajira upwelling, and climatological fronts in the outer continental shelf of the South Atlantic Bight. These two areas overlapped with fishing effort in the region for commercial longline and trawling. In the Caribbean Sea, use areas of Black-capped Petrels overlapped with oil and gas activities offshore of Colombia. Implications for future research include assessing at-sea threats associated with fisheries and oil and gas activities and those associated with urban lighting and terrestrial wind farms near flight paths to and from colonies.

#### USING PREDICTIVE HABITAT MODELLING TO LOCATE UNKNOWN NESTING AREAS OF THE ENDANGERED BLACK-CAPPED PETREL IN THE DOMINICAN REPUBLIC

Yvan G. Satgé (ysatge@g.clemson.edu)<sup>1</sup>, Ernst Rupp (ernst.rupp@grupojaragua.org.do)<sup>2</sup>, and Patrick G.R. Jodice (pjodice@g.clemson.edu)<sup>3</sup>

<sup>1</sup>South Carolina Cooperative Fish and Wildlife Research Unit, Clemson University, Clemson, SC USA 29634

<sup>2</sup>Grupo Jaragua, Santo Domingo, Dominican Republic

<sup>3</sup>U.S. Geological Survey South Carolina Cooperative Fish and Wildlife Research Unit, Clemson University, Clemson, SC USA 29634

The Diablotin (Black-capped petrel, *Pterodroma hasitata*) is one of only two extant seabird species endemic to the Caribbean. The species has a fragmented and declining population. While at-sea records suggest a population of ca. 5,000 individuals, the nesting population is estimated at ca. 1,000 breeding pairs. Primarily nocturnal and crepuscular on their breeding grounds, Black-capped Petrels nest underground, in steep ravines characterized by dense

and humid understory vegetation with loose rocks and soil allowing for burrow excavation. Until 2017, the only confirmed breeding sites were located in the mountain ranges of Haiti and the western Dominican Republic, where habitat loss and degradation are primary threats to the species and continuing conservation concerns. Recent work using radar has led to the discovery of a previously undetected nesting area in the central mountain range of the Dominican Republic. Other nesting populations may still remain undiscovered but *in situ* nest searches, which must be conducted over expansive geographical areas, are laborious and greatly limited by the undisturbed natural habitat being prospected. To focus nest-search efforts more efficiently we predicted suitable nesting areas for Black-capped Petrel in the Dominican Republic. Using openly available environmental datasets we determined the significant habitat characteristics of active nest sites. We then applied the best habitat suitability model to the GIS raster layers and classified all available habitat in the Dominican Republic. Future plans include testing this model with nest sites in Haiti before applying it to other Caribbean countries suspected to host nesting populations of Black-capped petrels.

#### ADAPTING MANAGEMENT PRIORITIES TO BUFFER EFFECTS OF CLIMATE CHANGE AT KURE ATOLL, HAWAII

Matthew Saunter (Matthew.K.Saunter@hawaii.gov), Naomi Worcester (Naomi.N.Worcester@hawaii.gov), Cynthia Vanderlip (KureAtoll@gmail.com)<sup>1</sup>

<sup>1</sup>Hawaii Department of Land and Natural Resources Division of Forestry and Wildlife, 2135 Makiki Heights Drive, Honolulu HI 96822 USA

Kure Atoll is the State of Hawai'i's most significant seabird sanctuary providing habitat for 18 seabird species, the critically endangered Laysan teal (*Anas laysanensis*) and Hawaiian monk seal (*Neomonachus schauinslandi*). Kure, the Pacific's northernmost atoll, is part of the Papahānaumokuākea Marine National Monument and lies 2,200 km northwest of Honolulu at a unique location referred to as the Darwin Point where coral accretion is equal to the rate of atoll subsidence. Considering this and the added effects of climate change, the State of Hawai'i is committed to prioritizing management objectives to reduce the potential for habitat loss and improve the island's resiliency. Management priorities include invasive plant eradication, native plant establishment, and reclaiming habitat on the interior of the island. Eradication programs were initiated in 2010 with an

intent to eliminate the atoll's most destructive plant species. Native plant propagation and establishment has complemented these efforts by replacing invasive species with soil-stabilizing native plant communities. In October 2017, field teams broke ground on a project to convert the decommissioned U.S. Coast Guard runway (7.3 ha) into suitable seabird nesting areas. This interior space is important for species susceptible to sea level rise and storm surge such as Black-footed albatross (*Phoebastria nigripes*) and will provide 10% more nesting space away from the exposed periphery of the island. With the ongoing management and restoration practices, Kure Atoll will continue to provide critical wildlife habitat while capacity is being built to expand species ranges to higher islands.

#### NESTING ATTEMPTS AND POST-BREEDING ROOST SITE USE OF CALIFORNIA BROWN PELICANS ON EAST SAND ISLAND, OREGON

Jordan Scheibe (jordanscheibe@gmail.com)<sup>1</sup>, Kirsten Bixler (kirsten.bixler@oregonstate.edu)<sup>1</sup>, Timothy Lawes (timothy.lawes@oregonstate.edu)<sup>1</sup>, Daniel Roby (daniel.robby@oregonstate.edu)<sup>1</sup>

<sup>1</sup>Oregon Cooperative Fish & Wildlife Research Unit, Department of Fisheries and Wildlife, Oregon State University, 104 Nash Hall, Corvallis, OR 97331 USA

California brown pelicans (*Pelecanus occidentalis californicus*) were federally listed as endangered in 1970 and delisted in 2009 following population recovery, but close monitoring of this species of conservation concern is still warranted. East Sand Island, located in the Columbia River estuary in Oregon, is the largest known post-breeding nighttime roost site for California brown pelicans, situated approximately 1500 km north of their nearest breeding colony. Since 2000, we have monitored brown pelicans on East Sand Island from mid-May to mid-September using boat-based surveys to count roosting pelicans in conjunction with land-based surveys of breeding activities. We observed brown pelicans displaying pre-breeding behaviors as early as 2009, but the first egg-laying did not occur until 2013. In 2013, 2014, and 2016, we documented 24 active nests and at least 10 eggs laid, all of which failed to produce young. The distribution of pelican roosting and nesting on East Sand Island has remained dynamic over the years, due in part to management activities associated with other nesting colonial waterbirds on the island. Since 2010, there has been a decline in the peak counts of pelicans roosting on the island; the number of pelicans using the island during the last

three seasons has been at nearly half of the long-term average. Also, pelican use of the island has peaked earlier in the year; peak counts occurred 37 days earlier on average during the last 5 years than the first 5 years of monitoring. Earlier migration to northern post-breeding roost sites may be indicative of failed nesting attempts at California breeding colonies, which may also offer an explanation for the nesting attempts observed on East Sand Island.

#### THE RESPONSE OF CASPIAN TERNS TO MANAGED REDUCTIONS IN NESTING HABITAT IN THE COLUMBIA PLATEAU REGION, WASHINGTON, USA

Ethan Schniedermeyer ([ethan.schniedermeyer@oregonstate.edu](mailto:ethan.schniedermeyer@oregonstate.edu)), Daniel D. Roby ([daniel.robby@oregonstate.edu](mailto:daniel.robby@oregonstate.edu)), Donald E. Lyons ([don.lyons@oregonstate.edu](mailto:don.lyons@oregonstate.edu)), and Yasuko Suzuki ([yasuko.suzuki@oregonstate.edu](mailto:yasuko.suzuki@oregonstate.edu))

•Oregon Cooperative Fish and Wildlife Research Unit, Department of Fisheries and Wildlife, Oregon State University, 104 Nash Hall, Corvallis, OR 97331, USA

Predation on smolts by Caspian Terns (*Hydroprogne caspia*) has been identified as a factor limiting the restoration of some populations of anadromous salmonids (*Oncorhynchus* spp.) from the Columbia River basin that are listed under the U.S. Endangered Species Act. Implementation of a management plan to prevent nesting by Caspian Terns at the two largest breeding colonies for the species in the Columbia Plateau region began in 2014 and is ongoing. We investigated the response of Caspian Terns to reductions in nesting habitat during 2014-2016. Management prevented terns from nesting at both colonies in 2015 and 2016, but failed to reduce the number of terns nesting in the region to the management target of less than 200 pairs. The number of nesting pairs in the region declined, however, from a historical average of 878 to 769 in 2015 and 675 in 2016; there was no significant change in nesting success. Analysis of resightings of banded individuals indicated that most Caspian Terns that nested in the Columbia Plateau region pre-management returned to the region in 2015 and 2016 (> 80%), but the proportion that returned as breeders decreased while the proportion that returned as non-breeding floaters or went unobserved increased compared to pre-management. The unexpectedly high regional philopatry exhibited by Caspian Terns during management years was likely a reflection of the low availability of suitable alternative nesting habitat outside the region. Most Caspian Terns that remained

in the region displayed considerable flexibility in nest site selection by nesting either at a previously smaller, intermittently successful breeding colony or at a small new colony where nesting activity had not previously been recorded.

#### COMMON MURRE AND BLACK-LEGGED KITTIWAKE BREEDING FAILURES IN COOK INLET, ALASKA FOLLOWING THE NORTH PACIFIC MARINE HEAT WAVE

Sarah Schoen ([sschoen@usgs.gov](mailto:sschoen@usgs.gov)), Mayumi Arimitsu ([marimitsu@usgs.gov](mailto:marimitsu@usgs.gov)), John Piatt ([jpiatt@usgs.gov](mailto:jpiatt@usgs.gov)), Brielle Heflin ([bheflin@usgs.gov](mailto:bheflin@usgs.gov)), and Caitlin Marsteller ([cmarsteller@usgs.gov](mailto:cmarsteller@usgs.gov))

•USGS Alaska Science Center, 4210 University Drive, Anchorage, AK USA 99508

•USGS Alaska Science Center, 250 Egan Drive, Juneau, AK USA 99801

The largest die-off of Common Murres (*Uria aalge*) ever recorded in the Pacific Ocean (2015-2016) followed a prolonged and extreme marine heat wave (MHW) in the North Pacific during 2014-2016. The evident cause of mortality was starvation, presumably due to insufficient forage. To detect population level effects following the MHW, we studied Common Murre and Black-legged Kittiwake (*Rissa tridactyla*) demographics at two breeding colonies in Cook Inlet, Chisik and Gull islands, during summers 2016-2018 and compared our findings with earlier demographic studies from 1995-1999. We censused whole colony populations and estimated productivity (# chicks fledged/eggs laid). Census counts for murres at Gull steadily declined from 7636 birds in 2016, when they were lower than historic levels (mean 8937±1852), to the lowest ever count of 3147 in 2018. In contrast, kittiwake counts at Gull increased from 5141 birds in 2016 to 7479 in 2018, similar to historic levels (mean 6988±1179). At Chisik, counts for both species were below historic estimates in all years. For the first time on record, murres at both colonies completely failed to fledge chicks from 2016-2018. Similarly, kittiwake productivity was at or near zero at both colonies in 2016 and 2018, and at Chisik in 2017. In 2017, however, kittiwake productivity at Gull was above average. In addition to these metrics, we also observed very emaciated murres attending colonies, which is unprecedented in our experience, and avian predators (eagles, falcons, gulls) disrupted nesting birds and consumed eggs with unusual frequency. Overall, seabird populations in Cook Inlet have not recovered



following the MHW, and continued breeding failures suggest a chronic scarcity of forage fish.

#### SPECIES RICHNESS PATTERNS AND INTERACTIONS AMONG ANTARCTIC BREEDING BIRDS

Michael Schrimpf<sup>1</sup> ([michael.schrimpf@stonybrook.edu](mailto:michael.schrimpf@stonybrook.edu)), Heather Lynch<sup>1</sup>

<sup>1</sup>Department of Ecology and Evolution, Stony Brook University, Stony Brook, NY, USA 11794-5245

\*Presenting author

Many seabirds nest together in dense multi-species colonies, which raises the question as to the relative role of habitat and interspecific interactions in determining the location of breeding sites. The Antarctic Peninsula contains hundreds of seabird colonies that are free from invasive land predators and most human-induced habitat loss, and therefore they provide an opportunity to investigate how the pattern of species overlap at those sites relates to habitat, bird abundance, and potential interactions among species. With opportunistic data on presence and absence collected over 22 years, we used an occupancy modeling approach that accounted for probability of detection to create the first set of comprehensive maps describing the pattern of breeding for the Antarctic Peninsula region's entire seabird community. Three areas (the South Shetland Islands, Northeastern Peninsula, and southern Gerlache Strait) had the highest concentration of breeding species, the latter two of which represent sea-ice ecotones. Each of those three areas also contained high concentrations of a different member of the *Pygoscelis* spp. penguins, suggesting both competitive exclusion among penguins, as well as a link between penguin abundance and the diversity of other seabirds. We believe the union of opportunistic surveys with modeling techniques normally applied to terrestrial fauna (i.e., occupancy) can help researchers disentangle the forces driving breeding distributions of seabird communities in regions with networks of colony locations.

#### LEACH'S STORM-PETRELS IN THE GULF OF MAINE: CURRENT POPULATION ESTIMATES FOR THE REGION'S TWO LARGEST COLONIES

Susan Schubel ([sschubel@audubon.org](mailto:sschubel@audubon.org))<sup>1</sup>, Paula Shannon ([pshannon@audubon.org](mailto:pshannon@audubon.org))<sup>1</sup>, and Iain Stenhouse ([iain.stenhouse@briloon.org](mailto:iain.stenhouse@briloon.org))<sup>2</sup>

<sup>1</sup>National Audubon Society Seabird Restoration Program, 12 Audubon Rd, Bremen, ME USA 04551

<sup>2</sup>Biodiversity Research Institute, 276 Canco Rd, Portland, ME USA 04103

Leach's Storm-Petrel (*Oceanodroma leucorhoa*) colonies in Atlantic Canada have experienced significant declines in the past 20 years, yet no population surveys have been conducted on the Atlantic coast of the United States since the mid-1990s. More than 99% of the U.S. population in the Northwest Atlantic breeds in Maine, and was estimated at 10,366 pairs when last surveyed (1994-1996). At that time, burrows were found on 36 islands. Only seven of these had more than 100 pairs, with 76% of the population breeding at just two sites - Great Duck Island and Little Duck Island. Both of these colony islands were surveyed again in 2018, using similar methods to the previous survey. Parallel transects were run every 50 m across each island, with 3 m radius circular plots set every 50 m along the transects. The number of burrow openings were counted in each plot. A separate index to calculate burrow occupancy rate was determined by surveying additional areas. Direct extrapolation of active burrow density across all petrel habitats on each island suggests that the number of active burrows on Little Duck Island and Great Duck island have increased significantly (more than doubled) since the mid 1990's. Occupancy rates on Great Duck Island were lower (0.43) than on Little Duck Island (0.55), perhaps due to the presence of introduced Snowshoe hares (*Lepus americanus*) which have removed much of the forest understory there. Our preliminary results suggest that the declining trends seen in Atlantic Canada's Leach's Storm-Petrel population may not be mirrored in peripheral colonies in the Gulf of Maine.

#### POTENTIAL TO TRACE CHEMICALS IN LAYSAN ALBATROSS (*PHOEBASTRIA IMMUTABILIS*) SIBLING EGGS

Alphabetized by Schuur

Colleen E. Bryan ([colleen.bryan@nist.gov](mailto:colleen.bryan@nist.gov)) and Stacy S. Schuur ([stacy.schuur@nist.gov](mailto:stacy.schuur@nist.gov))

National Institute of Standards and Technology, Chemical Sciences Division, Hollings, Marine Laboratory, 331 Fort Johnson Rd, Charleston, SC 29412

Laysan Albatross (*Phoebastria immutabilis*) have high site fidelity and generally maintain strong partner

bonds, which combined with banding, allows for repetitive monitoring of individuals. Abandoned eggs from female-female pairs and from BASH program relocation in Hawaii have been collected, processed, and banked for contaminant analysis and for use by requesting scientists as part of the interagency Seabird Tissue Archival and Monitoring Project (STAMP). Of the 215 eggs collected from Oahu and Kauai between 2010 and 2017, 118 (55 %) have potential siblings collected in subsequent years. Of these, 55 eggs collected between 2010 and 2014 with potential siblings were analyzed for mercury. There was no difference among colonies ( $p > 0.05$ ), so all data were combined. Eggs collected in 2010 and 2013 had significantly ( $p < 0.05$ ) greater mercury than those collected in 2014. The potential sibling pairs generally followed similar trends between years, but due to eggs from the same mother not being collected every year and the potential unknown of which mother laid the egg, statistical analysis was not feasible. Genetic testing to determine mother and analysis of organic contaminants would be useful. Aliquots of all banked eggs are available to other researchers through a published access policy.

#### PLASTIC INGESTION IN NORTHERN FULMARS (*FULMARUS GLACIALIS*) CAPTURED IN FISHERIES

Stacy S. Schuur (stacy.schuur@nist.gov)<sup>1</sup>\*, Shannon F. Fitzgerald (shannon.fitzgerald@noaa.gov)<sup>2</sup>, Sung Young Ha (syha@kiost.ac.kr)<sup>3</sup>, Sang Hee Hong (shhong@kiost.ac.kr)<sup>3</sup>, John R. Kucklick (John.Kucklick@nist.gov)<sup>1</sup>, Won Joon Shim (wjshim@kiost.ac.kr)<sup>3</sup>

<sup>1</sup>National Institute of Standards and Technology, Chemical Sciences Division, Hollings, Marine Laboratory, 331 Fort Johnson Rd, Charleston, SC 29412

<sup>2</sup>National Oceanic and Atmospheric Administration, Alaska Fisheries, Science Center, 7600 Sand Point Way NE, Seattle, WA 98115

<sup>3</sup>Korea Institute of Ocean Science and Technology, Oil and POPs Research Group, Geoje, 53201, Republic of Korea

Ubiquitous distribution of plastic debris around the world and the ingestion by seabirds is a growing environmental concern. As part of an international collaboration between Korea Ministry of Fisheries and the US Department of Commerce, we are investing in plastic debris ingested by marine organisms can transfer plastic-associated chemicals such as

plasticizers, flame retardants, and UV stabilizers to wildlife. We chose to examine northern fulmars (*Fulmarus glacialis*) due to their known ingestion of plastic debris. Fulmars that were incidentally caught in nine North Pacific fishery cruises were examined for plastic ingestion. As well, liver and samples fat were removed and frozen at -80 °C for later analysis to include plastic associated chemicals. Of the 43 birds, 27 had plastics in the digestive tract ranging from a single piece to 20 pieces and 0.0012 g to 1.95 g. The majority were post-consumer fragments (68 %) followed by fibers (20 %), pellets (8.6 %) and film (3.4 %). Polymer types of the ingested plastics were confirmed by Fourier transform infrared spectroscopy (FTIR). Polyethylene dominated with 73 % of the pieces and the rest were polypropylene (26 %) and nylon (0.6 %). Chemical contaminants will be examined in the fat and liver samples and correlated to amount of the ingested plastics and chemicals associated with them this summer.

#### CONTRIBUTIONS OF DIET COMPOSITION AND DAILY PROVISIONING RATES TO THE GROWTH AND SURVIVAL OF ATLANTIC PUFFIN CHICKS

Paula Shannon (pshannon@audubon.org)<sup>1</sup>\*, Keenan Yakola (kyakola@umass.edu)<sup>2</sup>, Stephen Kress (skress@audubon.org)<sup>3</sup>, and Susan Schubel (ssschubel@audubon.org)<sup>3</sup>

<sup>1</sup> National Audubon Society Seabird Restoration Program, 12 Audubon Road, Bremen, ME USA 04551

<sup>2</sup> University of Massachusetts Amherst, Amherst, MA USA 01003

<sup>3</sup> National Audubon Society Seabird Restoration Program, 159 Sapsucker Woods Rd, Ithaca, NY USA 14850

\* Presenting and corresponding author

Seabird chick growth and survival depends on the quality and quantity of provisioned prey items. After many of Maine's Atlantic Puffin (*Fratercula arctica*) chicks starved in 2013, despite receiving a diet composed primarily of "good" forage fish, it became apparent that a lack of provisioning rate data was limiting our understanding of the relationship between diet and productivity. To investigate the relative importance of prey quality and quantity to puffin chicks, we collected data on chick provisioning rates, diet composition, growth parameters, and survival at three mid-coast Maine colonies from 2015-2018. Provisioning rates were calculated from twice-per-week, all day feeding watches; diet composition

was determined from photographed bill-loads recorded over four 3-hour observation periods each week; and growth parameters and survival estimates were derived from chicks measured every 4-5 days. Productivity, chick growth, diet composition, and daily provisioning rates exhibited significant interannual variation and we found a strong correlation between the number of feedings per day and chick growth parameters. Provisioning rates and diet composition varied throughout the nesting season, likely driven by a combination of prey availability and the energetic needs of chicks. We explored the relationship between provisioning rates, diet composition, and growth using generalized additive models to test which combinations of prey and provisioning rates best explained chick growth. The results will provide insight into the adaptability of puffins to a changing prey base, as well as inform seabird and fisheries managers regarding the importance of forage fish for integration into ecosystem based fisheries management.

#### PARASITES AND MICROPLASTICS OF SEABIRDS FROM THE WESTERN ALEUTIAN ISLANDS, AK

Kate L. Sheehan (klsheehan@saumag.edu)<sup>1</sup>, Ryan F. Hechinger (rhechinger@ucsd.edu)<sup>2</sup>, Veronica Padula (vmpadula@alaska.edu)<sup>3</sup>, Douglas Causey (dcausey@alaska.edu)<sup>3,4</sup>

<sup>1</sup>Southern Arkansas University, Magnolia AR USA

<sup>2</sup>University of California San Diego, La Jolla CA USA

<sup>3</sup>Dept Fisheries, U Alaska Fairbanks, Fairbanks, AK 99775

<sup>4</sup>Dept Biological Sciences, U Alaska Anchorage, Anchorage, AK 99508

While foraging, seabirds can consume food items that transmit parasitic worms and they also can consume plastic particles. Here, we document the prevalence, abundance, and interactions of plastics and parasites within the digestive tracts of Pacific seabirds collected from the western Aleutian archipelago in Alaska USA. We found a trend for parasite prevalence to be negatively associated with the prevalence of microplastics. When seabirds consumed plastic particles, parasites were found in fewer components of the digestive tract. We also found a negative association between plastic consumption and species richness of parasites in seabirds. The mechanism that could be driving a reduction of parasites in seabirds that consume plastics has not been tested; however, phthalate concentrations for the same dataset

suggests that plastics could influence parasites. Because parasites and consumed plastics persist in the same environment within seabirds, parasites are exposed to concentrations of toxic compounds like phthalates. We found a positive relationship between the prevalence of plastics found and the phthalate concentration of seabirds, and in birds with higher phthalate concentrations, found fewer parasites. These differences could also be related to trophic position of a seabird: higher order predators tended to have fewer microplastic particles, lower phthalate, and a higher infection rates of parasites. This preliminary research shows promising prospects for further avenues for further research on seabirds as predators, hosts to parasites, and consumers of plastic pollution.

#### TEMPORAL DYNAMICS OF NUTRITIONAL STRESS AND DIET OF RHINOCEROS AUKLETS BREEDING ON TWO DISTANT COLONIES IN JAPAN.

Ui Shimabukuro (shimabukuro.ui@nipr.ac.jp)<sup>1</sup>, Akinori Takahashi (atak@nipr.ac.jp)<sup>1,2</sup>, Jumpei Okado (s02119172c@gmail.com)<sup>3</sup>, Nobuo Kokubun (kokubun@nipr.ac.jp)<sup>3</sup>, Jean-Baptiste Thiebot (jbthiebot@gmail.com)<sup>3</sup>, Alexis Will (awill4@alaska.edu)<sup>2,4</sup>, Yutaka Watanuki (ywata@fish.hokudai.ac.jp)<sup>3</sup>, Alexander Kitaysky (askitaysky@alaska.edu)<sup>4</sup>

<sup>1</sup>Department of Polar Science, SOKENDAI (The Graduate University for Advanced Studies), 10-3, Midori-cho, Tachikawa-shi, Tokyo 190-8518, Japan

<sup>2</sup>National Institute of Polar Research, 10-3, Midori-cho, Tachikawa-shi, Tokyo 190-8518, Japan

<sup>3</sup>Graduate School of Fisheries Sciences, Hokkaido University, Minato-cho 3-1-1, Hakodate, Hokkaido 041-8611, Japan

<sup>4</sup>Department of Biology and Wildlife, Institute of Arctic Biology, University of Alaska Fairbanks, 311 N. Koyukuk Dr., Fairbanks, Alaska 99775, USA

Oceanographic regime shifts are known to affect the food availability and reproductive success of piscivorous seabirds. In the northwestern Pacific, breeding rhinoceros auklets (*Cerorhinca monocerata*) have been relying on the Japanese Anchovy as a primary food source for the last two decades, but the stock of anchovies has declined in recent years. To understand the effect of anchovy shortages on nutritional stress levels of rhinoceros auklets, we measured corticosterone (CORT) concentrations in blood plasma samples of birds breeding on Teuri (northern Japan Sea) and Daikoku (western Pacific

coast) Islands, Japan, in 2015-2017. We also sampled food loads brought by adults to feed their chicks. We found that plasma CORT levels were elevated on Teuri and Daikoku compared to those in rhinoceros auklets breeding on other colonies under favorable foraging conditions. This indicates that birds breeding on Teuri and Daikoku colonies were negatively affected by the decline in anchovies. CORT levels were also higher on both colonies in 2016 than in 2015 and 2017, which was associated with the lower average mass of food loads delivered by parents in 2016 compared to 2015 and 2017. The species composition of food loads, however, differed between the two locations, and did not correlate with nutritional stress. During the study period no single species appears to have replaced anchovy as the preferred prey. We suggest that these consistent patterns in inter-annual changes in the birds' food load mass and nutritional stress between two distant colonies may reflect a recent large-scale oceanographic regime shift in the northwestern Pacific. This ecological change might negatively affect the regional population of rhinoceros auklets.

#### DIVING AND FLYING ACTIVITY OF RHINOCEROS AUKLETS (*CERORHINCA MONOCERATA*) DURING THE NON-BREEDING PERIOD

Ui Shimabukuro (shimabukuro.ui@nipr.ac.jp)<sup>1</sup> and Akinori Takahashi (atak@nipr.ac.jp)<sup>1,2</sup>

<sup>1</sup>Department of Polar Science, SOKENDAI (The Graduate University for Advanced Studies), 10-3, Midori-cho, Tachikawa-shi, Tokyo 190-8518, Japan  
<sup>2</sup>National Institute of Polar Research, 10-3, Midori-cho, Tachikawa-shi, Tokyo 190-8518, Japan

Seabirds adjust their behavioral time budget in response to changes in food conditions during the breeding period, but less is known about their responses to conditions during the non-breeding period. Rhinoceros auklets (*Cerorhinca monocerata*) on Teuri Island, Japan, migrate to the Sea of Okhotsk and Sea of Japan after breeding, and molt their primary feathers in autumn. Their diving activities have been studied extensively during the chick-rearing period, but not during the non-breeding period. Here we recorded the diving depth and immersion time of three rhinoceros auklets during the non-breeding period using leg-mounted geolocators with depth sensors. Depth and immersion data (recorded every two minutes) were used to infer daily dive and flight times as well as maximum dive depths. The auklets showed little flight time (<1 hr/day) for about 7 weeks in mid-

August to September while they were in the Sea of Okhotsk, suggesting that they molted primary feathers during this period. During this molt period, daily dive times were shorter and maximum dive depth shallower, suggesting that the molt of primary feathers slightly compromised their diving ability. Dives occurred mostly between sunrise and sunset, and were deeper during winter, when auklets were in the Sea of Japan. They increased daily dive time in winter, presumably to gain energy stores in preparation for the return migration to the breeding colony and upcoming reproductive effort. Our results suggest that rhinoceros auklets adjust their diving activity and behavioral time budget in response to molt and energy demanding pre-breeding period in winter.

#### SOLUTIONS TO PROTECT STORM-PETRELS BETWEEN MINING DEVELOPMENT, MILITARY EXERCISES AND AN ARTIFICIALLY ILLUMINATED LANDSCAPE

Rodrigo Silva<sup>1</sup> (rodrigossilva@redobservadores.cl), Fernando Medrano<sup>1</sup>, Ivo Tejeda<sup>1</sup>, Daniel Terán<sup>1</sup>, Ronny Peredo<sup>1</sup>, Rodrigo Barros<sup>1</sup>, Peter Hodum<sup>2</sup>, Hannah Nevins<sup>3</sup>, Brad Keitt<sup>3</sup>, Vinko Malinarich<sup>4</sup>, Frederick Toro<sup>5</sup>, Verónica González<sup>6</sup> and Pedro Sanhueza<sup>7</sup>.

<sup>1</sup> Red de Observadores de Aves y Vida Silvestre de Chile

<sup>2</sup> Oikonos

<sup>3</sup> American Bird Conservancy

<sup>4</sup> Servicio Agrícola y Ganadero Tarapacá

<sup>5</sup> Panthalassa

<sup>6</sup> Voluntarios por las Golondrinas de mar de Iquique

<sup>7</sup> Observatorio de la calidad de los cielos del norte de Chile

Light pollution is an emergent threat for seabirds throughout the world, affecting especially petrels and shearwaters. In South America there does not exist any analysis compiling the available information on affected species, and only a few management measures have been implemented. We present a synopsis of affected species in Chile, the experiences trying to reduce the impact of light pollution, and proposals for approaching the issue from technical and political standpoints. We found that 12 species have been affected, including Shearwaters, Gadflies, Diving-petrels and Storm-petrels. Two remarkably findings are: (i) the massive fallout events recorded for Markham's Storm-Petrel (*Hydrobates markhami*) and (ii) the affection of Peruvian Diving-petrel (*Pelecanoides garnotii*), classified as endangered at

national level even without consider the light pollution threat. Most of the experiences in mitigation are related to the rescue and release of individuals, but there is uncertainty about their effectiveness. There is just one effective experience of replacement of conflictive lights, near the Pink-footed shearwater (*Ardenna creatopus*) colonies in Juan Fernandez Archipelago. We propose that the reduction of light pollution is possible, especially near the colonies, by turning off the lights during breeding seasons, replacing cold lights by warm lights and avoiding massively-lighted sporting events at night. Monitoring programs including active searches are required to increase the scope of rescue programs, but also to improve the understanding of fallout in Chile. This could be regulated by national public policies, but it will be important to work with local administrations to ensure promotion and inspection.

#### SURVIVAL AND NEST-SITE FIDELITY OF REHABILITATED CASPIAN TERNS IN SOUTHERN CALIFORNIA

Julie Skoglund (Julie.Skoglund@bird-rescue.org)<sup>1</sup> and Charles T. Collins (Charles.Collins@csulb.edu)<sup>2</sup>

<sup>1</sup>International Bird Rescue, Los Angeles Center, 3601 South Gaffey Street, San Pedro, California 90731

<sup>2</sup>Department of Biological Sciences, California State University Long Beach, California 90840-3702

Every year nationwide, thousands of wild animals, are brought into care centers for rehabilitation and, hopefully, return to the wild (McRuer et al. 2017). Prominent among the birds rehabilitated are victims of oil spills and other anthropogenic activities (Duerr et al. 2016, Henkel and Ziccardi 2018). In southern California, International Bird Rescue (hereafter “IBR”) rehabilitates and releases 300-500 aquatic birds on average annually. Terns are uncommon patients at IBR, and are almost always admitted due to fishing gear injuries or entanglement (IBR, unpublished data). Although IBR bands all birds at release and has banded more than 24,000 rehabilitated birds since 2002, band recoveries are not common, typically 0.5-8.0% of released birds depending on species (Duerr et al., in prep.). It is not known how many survive and rejoin breeding populations. In 2007 a sea-going barge docked in Long Beach Harbor (California) became a nesting colony for approximately 100 pairs of Caspian Terns (*Hydroprogne caspia*). Due to various factors (height of barge, harbor activity, etc.) a number of the fledgling

Caspian Tern chicks required rescue and rehabilitation after falling and/or fledgling from the deck of the boat into the water. Recently we have obtained band observations of several of the rescued and rehabilitated Caspian Terns in southern California rejoining a breeding population following rehabilitation and showing subsequent nest-site fidelity. This poster will review the details of their rescue and rehabilitation in addition to presenting the band observations.

#### REPORT ON THE SEABIRD RECOVERY EFFORT ON DESECHEO ISLAND, PUERTO RICO Alphabetized by Spatz and also by Herrera

Jose Luis Herrera (jose.herrera@islandconservation.org)<sup>1</sup>, Cielo Figuerola (cielo.figuerola@islandconservation.org)<sup>1</sup>, Susan Silander (susan\_silander@fws.gov)<sup>2</sup>, Coral Wolf (coral.wolf@islandconservation.org)<sup>1</sup>, Dena Spatz (denarspatz@gmail.com)<sup>3</sup>\*, Nick Holmes (nick.holmes@islandconservation.org)<sup>1</sup>

<sup>1</sup>Island Conservation, 2100 Delaware Ave, Santa Cruz CA 95060

<sup>2</sup>U.S Fish and Wildlife Service – Caribbean National Wildlife Refuge Complex, PO Box 510, Boqueron, Puerto Rico 00622-0510

<sup>3</sup>Presenting Author

On Desecheo Island National Wildlife Refuge, Puerto Rico, the introduction of invasive mammals such as feral goats, cats, black rats and rhesus macaques, as well as the use of the island as a bombing range, has nearly extirpated all seabird species that once regularly bred on the island. Restoring the island ecosystem has been a clear goal for US Fish and Wildlife Service, with emphasis on native seabirds, endemic reptiles and threatened plants. In 2017, after 10+ years of significant effort, Desecheo was declared free of invasive mammals, providing a foundation to begin additional restoration action for native species. Working with U.S Fish and Wildlife Service, we examined the historic breeding distribution of seabirds on the island, then applied that knowledge to the planning and implementation of a social attraction project for Bridled Tern (*Onychoprion anaethetus*) and Audubon’s Shearwater (*Puffinus lherminieri*) in 2018. Here we report on promising preliminary results after the first year of observation.

## CREATING A GLOBAL DATABASE OF ACTIVE SEABIRD RESTORATION PROJECTS

Dena Spatz (denarspatz@gmail.com)<sup>1</sup>, Nick Holmes (twothylacines@gmail.com)<sup>1</sup>, Lindsay Young (lindsay@pacificrimconservation.com)<sup>1</sup>, Eric VanderWerf (eric@pacificrimconservation.org)<sup>1</sup>, Holly Jones (hjones@niu.edu)<sup>2</sup>, Brad Keitt (bkeitt@abcbirds.org)<sup>3</sup>, Steve Kress (skress@audubon.org)<sup>4</sup>

- <sup>1</sup>. Pacific Rim Conservation, PO Box 61827, Honolulu, Hawaii, 96839
- <sup>2</sup>. Northern Illinois University, 1425 W. Lincoln Hwy, DeKalb, IL 60115
- <sup>3</sup>. American Bird Conservancy, 4301 Connecticut Ave, NW Suite 451 Washington, D.C. 20008
- <sup>4</sup>. National Audubon Society, Seabird Restoration Program, 159 Sapsucker Woods Rd., Ithaca, NY 14850

Seabirds are globally threatened, yet there are abundant examples of positive outcomes following management actions, such as the removal of invasive species from breeding islands. Active restoration - social attraction by acoustic or visual stimuli, and chick translocation - can be applied where removal of key threatening processes like invasive species is not enough for the long-term conservation of a species. These activities can increase seabird populations and aid in species extinctions. Additional benefits include expanded ranges and reestablished marine and terrestrial connectivity and function, because seabirds are ecosystem engineers in these two systems. However, there is a lack of common knowledge of how to select and apply active restoration methods with the greatest chances of success. An opportunity exists to build on a previous review by Jones and Kress (2012), which was the first attempt to consolidate active seabird restoration activities and provide case studies to help optimize re-colonization tools. We seek to undertake a global synthesis of seabird translocation and social attraction projects in partnership with other seabird restoration practitioners and experts to enable broader use of these techniques. The review will result in a dataset of active seabird restoration projects from around the world - where they are happening, the species and objectives targeted, the methods and costs of the activity, and the restoration outcome. We will also provide basic analyses of trends and knowledge gaps to enhance seabird conservation activities and assist seabird managers and researchers worldwide.

## EVALUATING CURRENT LIMITING FACTORS AND FUTURE THREATS TO RECOVERY OF ENDANGERED ROSEATE TERNS

Jeff Spindel (JSpindel@usgs.gov)

12421 Galway Drive, Silver Spring, MD 20904  
[Emeritus Research Wildlife Biologist, USGS]

The endangered Northwest Atlantic breeding population of Roseate Terns (*Sterna dougallii*) dropped by >25% from a high of about 4,300 "peak period" breeding pairs in 2000 to about 3,000 "peak period" pairs in 2008. The most important factors that caused the decline have not been determined, but the relatively slow rate of population growth from 2008-2013 compared to the greater rate of growth from 1992-2000 indicated that there had been a major change in one or more aspects of the population dynamics of this species. The US Geological Survey - Patuxent Wildlife Research Center's Cooperative Roseate Tern Metapopulation Project (CRTMP) has been integrating results of several research studies to evaluate the relative importance of current factors and future threats to population recovery operating throughout the species range, but with a special focus on the factors operating at the major staging sites in the Massachusetts-New York area where most of the population concentrates for several months before migrating to South America.

## CHANGES IN PREDATOR ACTIVITY AND HAWAIIAN PETREL REPRODUCTIVE SUCCESS IN RESPONSE TO LANDSCAPE-LEVEL PREDATOR CONTROL

Rachel S. Sprague (rsprague@pulamalanai.com)<sup>1</sup>, Tyler Bogardus (tyler.bogardus@gmail.com)<sup>2</sup>, and André F. Raine (araine6@hawaii.edu)<sup>3</sup>

<sup>1</sup>Pūlama Lānaʻi Department of Natural Resources, 1311 Fraser Ave., P.O. Box 630310, Lanai City, HI 96763, rsprague@pulamalanai.com

<sup>2</sup>Grey Boar Wildlife Services, Honolulu, HI, tyler.bogardus@gmail.com

<sup>3</sup>Kauaʻi Endangered Seabird Recovery Project, 3900 Hanapepe Rd, Hanapepe, HI 96716, araine6@hawaii.edu

The island of Lānaʻi is home to an important nesting colony of endangered Hawaiian petrels (*Pterodroma sandwichensis*). A growing landscape-level predator trapping network has been implemented to protect the colony from depredation by non-native rats and cats. Over 3 years, the trap network has grown to include

120 cat traps over 17+ km of trails in an approximate 250m x 1km spacing, and nearly 400 Good Nature A24 automatic rat traps covering ~130 ha of nesting habitat in spacing ranging from 50x100 m to 50x50 m depending on the topography. With this protection, black rat visitations to camera-monitored petrel burrows in proximity to A24 traps significantly decreased, as did cat visitations and depredations of petrels by rats and cats. From just 2016 to 2017, Hawaiian petrel reproductive success more than tripled, from 22% to 78.4% in the area with the most concentrated predator control, and an increase from 17% to 67% in the secondary areas with moderate predator control. Since the initial trapping network expansion, we are now starting to look spatially at the instances of predator sightings and depredations within the colony to inform potential modifications to the trapping grids to improve protection.

#### PIGEON GUILLEMOTS REBOUND AS INTRODUCED MINK ARE REMOVED

Sam B. Stark (sam.stark@oregonstate.edu)<sup>1\*</sup>, Daniel D. Roby (daniel.roby@oregonstate.edu)<sup>1</sup>, and David B. Irons (dbironsak@gmail.com)<sup>2</sup>

<sup>1</sup>Oregon Cooperative Fish and Wildlife Research Unit, Department of Fisheries and Wildlife, 104 Nash Hall, Oregon State University, Corvallis, OR 97331 USA

<sup>2</sup>U.S. Fish and Wildlife Service (retired), Migratory Bird Management, 1011 East Tudor Road, Anchorage, AK 99503 USA

Removal of introduced predators is a widespread and effective tool for restoration of island nesting birds. Despite its pervasive use, the effects of predator removal on target species for conservation remains understudied. Pigeon Guillemots (*Cephus columba*) are a crevice-nesting alcid native to the northeastern Pacific that has experienced local declines where predators were introduced to breeding islands. The population of guillemots at the Naked Island Group in Prince William Sound, Alaska declined 95% from 1979 to 2008, concurrent with reports of the intentional introduction of American mink (*Neovison vison*) to the Group. Although mink removal from an island had not been previously attempted in North America, removal commenced in 2014. We monitored guillemots at the Naked Island Group from 2012 to 2018. During that time, we observed a 145% increase in the number of guillemots attending breeding colonies on the Naked Island Group, an increase not observed at other nearby guillemot colonies on mink-free islands. Following

mink removal we also observed a 206% increase in the number of active guillemot nests and a 4-fold increase in the proportion of active nests in sites vulnerable to mink predation. Overall predation rates on guillemot nestlings at the Naked Island Group decreased from an average of 34% pre-mink removal to 6% post-mink removal, similar to the average predation rate of 10% observed pre-mink introduction. Our results indicate that the removal of mink from the Naked Island Group has been successful in initiating recovery of the local guillemot breeding population. Future monitoring will determine if current trends in population growth of the Pigeon Guillemot population at the Naked Island Group continue.

#### INFLUENCE OF BODY CONDITION AND ARRIVAL DATE ON BREEDING SUCCESS OF THE ADÉLIE PENGUIN (*PYGOSCELIS ADELIAE*)

Katelyn Stoner (kastoner@comcast.net)<sup>1</sup>, Amélie Lescroël (alescroel@pointblue.org)<sup>1</sup>, Annie Schmidt (aschmidt@pointblue.org)<sup>1</sup>, Grant Ballard (gballard@pointblue.org)<sup>1</sup>, Katie M. Dugger (katie.dugger@oregonstate.edu)<sup>2</sup>, Megan Elrod (melrod@pointblue.org)<sup>1</sup>, and David Ainley (dainley@penguinscience.com)<sup>3</sup>

<sup>1</sup>Point Blue Conservation Science, Petaluma, CA 94954, USA

<sup>2</sup>U.S. Geological Survey, Oregon Cooperative Fish and Wildlife Research Unit, Department of Fisheries and Wildlife, Oregon State University, Corvallis, OR 97331, USA

<sup>3</sup>H.T. Harvey & Associates Ecological Consultants, Los Gatos, CA 95032, USA

Investigations of Adélie penguin (*Pygoscelis adeliae*) ecology have primarily been conducted during the breeding season. However, experiences in one period of the annual cycle may influence outcomes and processes at a later period. Individuals vary in their responses to environmental conditions, and some appear more capable of buffering adverse winter conditions, possibly leading to earlier arrival dates on their breeding grounds, better condition on arrival, and higher subsequent breeding success. We explored potential impacts of winter conditions on Adélie penguins at Cape Crozier on Ross Island, Antarctica. The Cape Crozier colony is one of the largest known colonies of Adélie penguins, and breeding ecology has been continuously monitored at this location for over 20 years. As part of an intensive, ongoing tagging effort, body condition and arrival date were recorded

for ~100 individuals of known-age, breeding history, and breeding quality in 2017-18 and 2018-19. Body condition was calculated from mass and torso circumference measurements taken within 1-2 days of arrival at the breeding colony and corrected for structural body size using measurements of bill and flipper length. We used these data to test 1) if better body condition at the beginning of the breeding season led to greater breeding success, possibly through higher investment in parental care and 2) if birds of higher breeding quality arrived at breeding sites earlier and/or in better body condition.

#### LOCAL ECOLOGICAL KNOWLEDGE AND PERCEPTIONS OF SMALL-SCALE FISHERS ON NON-TARGET TAXA CONSERVATION IN CHILE

Cristián G. Suazo (biosuazo@gmail.com)<sup>1,2,\*</sup>, Cristóbal Anguita (cristobalanguita@yahoo.com)<sup>3</sup>, Guillermo Luna-Jorquera (gluna@ucn.cl)<sup>4</sup>, Maritza Sepúlveda (maritza.sepulveda@uv.cl)<sup>5,6</sup>, and Jaime Ojeda (jaimeojedav@gmail.com)<sup>7</sup>

<sup>1</sup>Department of Animal Ecology and Systematics, Justus Liebig University Giessen, Heinrich-Buff-Ring 26-32, 35392 Giessen, Germany

<sup>2</sup>Albatross Task Force, BirdLife International-CODEFF, Chile

<sup>3</sup>Departamento de Ecología y Biodiversidad, Facultad de Ecología y Recursos Naturales, Universidad Andrés Bello, República 470, Santiago, Chile

<sup>4</sup>Universidad Católica del Norte, Millennium Nucleus of Ecology and Sustainable Management of Oceanic Island (ESMOI), Larrondo 1281, Coquimbo, Chile

<sup>5</sup>Centro de Investigación y Gestión de los Recursos Naturales (CIGREN), Instituto de Biología, Facultad de Ciencias, Universidad de Valparaíso, Gran Bretaña 1111, Playa Ancha, Valparaíso, Chile

<sup>6</sup>Millennium Nucleus of Invasive Salmonids (INVASAL), Concepción, Chile

<sup>7</sup>School of Environmental Studies, University of Victoria (BC), Canada

\*Presenter

Plans to reduce the negative impacts of fisheries on ecosystems, often come into conflict with fishermen who hold different experiences and perceptions on biodiversity. We interviewed fishermen along 2400 km of the Humboldt Current System, assessing their perceptions of the impacts of marine megafauna on fishing, and proposals to reduce conflicts with small-scale net fisheries. Seabirds were positively recognized as indicators of fish presence along this

system by vessel captains (mean probability 62.7%). Whilst sea lions were negatively recognized as causing damage to both catches and fishing gear as gillnets (97.1%). Among different potential measures to reduce conflicts with non-target taxa suggested by fishermen, night fishing and Marine Protected Areas were seen as the least probable measures (6% and 13.1%, respectively). In contrast, economic compensation and culling of currently protected sea lions were the most popular but also sensitive measures (31% and 33%, respectively). Different dimensions of experiences and perceptions of fishermen are key to the bottom-up understanding of interactions in small-scale fisheries, especially when measures to mitigate their impacts do not have any consolidated installation/monitoring, a contingent challenge for these types of fisheries globally. This study emphasizes the role of small-scale fishermen as a source of diverse ecological experiences and perceptions to complement knowledge on sensitive conservation issues.

#### SEABIRD BYCATCH IN PURSE SEINE FISHERIES: THE CASE OF THE MODIFIED PURSE SEINE AS A NOVEL MITIGATION MEASURE

Cristián G. Suazo (biosuazo@gmail.com)<sup>1,\*</sup>, Patricio Ortiz (portizsoazo@gmail.com)<sup>2</sup>, Rory Crawford (Rory.Crawford@rspb.org.uk)<sup>3</sup>, and Esteban Frere (estebanfrere@yahoo.com.ar)<sup>4</sup>

<sup>1</sup>Albatross Task Force, BirdLife International-CODEFF, Chile

<sup>2</sup>BirdLife International Marine Programme, c/o RSPB, The Lodge, Potton Road, Sandy, Bedfordshire SG19 2DL, UK

<sup>3</sup>Centro de Investigaciones Puerto Deseado, Universidad Nacional de la Patagonia Austral, CONICET. Av. Prefectura Naval S/N Puerto Deseado, Santa Cruz, Argentina

\*Presenter

Purse seine fisheries are globally distributed but scarcely understood in regard to their impacts on non-target species. Knowledge on bycatch issues was restricted to interactions with purse seine vessels targeting tuna and the conservation actions focused mainly on megafauna such as dolphins. However, ~35 species are by caught in coastal purse seine (industrial and small-scale) targeting mainly on forage fish identified for eight countries in seven FAO's marine areas being a phenomenon at international scale. The "Modified Purse Seine (MPS)" is one of the first



experimental measures to mitigate seabird bycatch in purse seine fisheries, where the modification of critical interaction structures in the fishing gear accounted in a reduction by ~98% in the seabird bycatch rates between modified nets and control (unmodified) fishing gear. Species involved in such reduction were plunge and pursuit diving seabird species such as Peruvian pelican *Pelecanus thagus* and pink-footed shearwater *Ardenna creatopus*, respectively. The MPS is derived from collaborative work between fishers, vessel owners, fishing gear manufacturers and seabird researchers. Thus, empirical data from *in situ* monitoring under commercial conditions identified sources of seabird bycatch in purse seine gear and informed the design of innovative technical mitigation measures, with an emphasis on different seabird species in the assemblage associated with this fishery in south-central Chile.

#### ECOSYSTEM RESPONSE TO A MARINE HEAT WAVE IN THE GULF OF ALASKA: SEABIRDS ARE THE TIP OF THE ICEBERG

Robert Suryan(rob.suryan@noaa.gov)<sup>1</sup>, Stephani Zador (stephani.zador@noaa.gov)<sup>2</sup>, Mandy Lindeberg (mandy.lindeberg@noaa.gov)<sup>3</sup>, Mayumi Arimitsu (marimitsu@noaa.gov)<sup>3</sup>, John Piatt (jpiatt@usgs.gov)<sup>4</sup>, John Moran (john.moran@noaa.gov)<sup>1</sup>, Janice Straley (jmstraley@alaska.edu)<sup>5</sup>, Heather Coletti (heather\_coletti@nps.gov)<sup>6</sup>, Dan Monson (dmonson@usgs.gov)<sup>7</sup>, Scott Hatch (shatch.isrc@gmail.com)<sup>8</sup>, Thomas Dean (tomdean@coastalresources.us)<sup>9</sup>, Russell Hopcroft (rrhopcroft@alaska.edu)<sup>8</sup>, Sonia Batten (sonia.batten@mba.ac.uk)<sup>9</sup>, Seth Danielson (sldanielson@alaska.edu)<sup>8</sup>, Brenda Konar (bhkonar@alaska.edu)<sup>8</sup>, Katrin Iken (kbiken@alaska.edu)<sup>8</sup>, Benjamin Laurel (ben.laurel@noaa.gov)<sup>10</sup>, Robert Campbell (rcampbell@pwssc.org)<sup>11</sup>, Mary Anne Bishop (mbishop@pwssc.org)<sup>11</sup>, Anne Shaefer (mbishop@pwssc.org)<sup>11</sup>, Scott Pegau (wspegau@pwssc.org)<sup>11</sup>, Kathy Kuletz (kathy\_kuletz@fws.gov)<sup>12</sup>, Robb Kaler (robert\_kaler@fws.gov)<sup>12</sup>, David Irons (dbironsak@gmail.com)<sup>12</sup>

<sup>1</sup>NOAA Fisheries, Alaska Fisheries Science Center, Auke Bay Laboratories, Juneau, Alaska, USA

<sup>2</sup>NOAA Fisheries, Alaska Fisheries Science Center, Seattle, Washington, USA

<sup>3</sup>U.S. Geological Survey, Alaska Science Center, Juneau Alaska, USA

<sup>4</sup>U.S. Geological Survey, Alaska Science Center, Anchorage, Alaska, USA

<sup>5</sup>University of Alaska Southeast, Sitka, Alaska, USA

<sup>6</sup>National Park Service, Fairbanks, Alaska, USA

<sup>7</sup>Coastal Resources Associates, Carlsbad, California, USA

<sup>8</sup>University of Alaska Fairbanks, Fairbanks, Alaska, USA

<sup>9</sup>Marine Biological Association of the UK, Nanaimo, BC, Canada

<sup>10</sup>NOAA Fisheries, Alaska Fisheries Science Center, Fisheries Behavioral Ecology Program, Newport, Oregon, USA

<sup>11</sup>Prince William Sound Science Center, Cordova, Alaska, USA

<sup>12</sup>U.S. Fish and Wildlife Service, 1011 E. Tudor Road, Anchorage, Alaska, USA

Multiple seabird mortality events have been attributed to a marine heatwave in the Northeast Pacific that began during the winter of 2013/14. The effects of the heatwave were far-reaching, from offshore pelagic to nearshore intertidal species and across multiple life stages. Diverse biological responses in the Gulf of Alaska (GOA) included reproductive failures and starvation in seabirds and marine mammals, changes in predator foraging behavior, changes in prey availability and energy content, presence of species not often found in Alaska, and wide-spread effects on typically resilient intertidal organisms. The timing and magnitude of responses varied, however, and is likely due at least in part to ecosystem complexity and heterogeneity across the GOA. For example, while upper water column temperature in large portions of the GOA trended back toward long-term mean values by the spring of 2017, temperatures at depth and in some inside waters such as Prince William Sound remained elevated through 2017 and 2018. Furthermore, many biological responses persisted into 2018. Densities of forage fish, marine birds, killer whales, and humpback whales were below normal in coastal areas through fall of 2018. Our results indicate that while the onset of the marine heatwave may be well defined, the end is uncertain given that the return to baseline for many metrics, particularly biological, has not yet occurred. This large-scale marine climate event offers an opportunity to understand variability in ecosystem response, which is especially relevant given a predicted increase in the frequency of marine heatwaves under climate change projections.

SO REALLY, WHAT ARE MAJOR THREATS TO  
SEABIRDS? COMPREHENSIVE GLOBAL ASSESSMENT  
Alphabetized by Suzuki

Maria Dias ([maria.dias@birdlife.org](mailto:maria.dias@birdlife.org))<sup>1</sup> and Yasuko  
Suzuki ([yasuko.suzuki@birdlife.org](mailto:yasuko.suzuki@birdlife.org))<sup>2\*</sup>

<sup>1</sup>BirdLife International Marine Programme, The David  
Attenborough Building, Pembroke Street, Cambridge,  
CB2 3QZ UK

<sup>2</sup>BirdLife International Marine Programme, 1-13-1  
Nihonbashi Kakigara-cho, Chuo-ku, Tokyo, 103-0014  
Japan

\* Presenting author

Previous reviews of threats to seabirds at a global level have focused on understanding the major drivers of declines of specific seabird groups, or on the impact of a single threat. The only global review of threats to seabirds to date focused solely on globally threatened species. In this study, we quantitatively evaluated 18 categories of threats to 360 extant species of seabirds, the first comprehensive global review to also include non-threatened species. We revealed that five threats have been the major drivers of the overall decline of seabird species globally: invasive alien species, bycatch, climate change/severe weather, hunting/trapping, and overfishing. Collectively, these threats affect almost 80% of seabird species and several millions of individuals globally. Each seabird species is affected by ca. three threats on average. Comparing to findings from a previous study focusing only on globally threatened species, the threat from marine pollution has decreased, whilst threats related to fishing, such as bycatch and overfishing, increased. The presence of invasive alien species at colonies is the main terrestrial threat to seabirds, affecting almost half of the species across different groups. Bycatch is the major threat in the marine realm and the threat causing higher impacts on average. Most threats, even the well understood ones with practical solutions, continue to drive decline both in globally threatened species and currently still common and abundant species. Findings of this study emphasize the need to understand cumulative impacts of multiple stressors on seabirds, as well as to further conservation efforts through wider use of best practices to mitigate threats to seabirds.

A SPATIALLY AND LIFE-HISTORY EXPLICIT MODEL  
TO INFORM MANAGEMENT OF CASPIAN TERNS IN  
THE PACIFIC FLYWAY OF NORTH AMERICA

Yasuko Suzuki ([yasuko.suzuki@oregonstate.edu](mailto:yasuko.suzuki@oregonstate.edu))<sup>1\*</sup>,  
Julie A. Heinrichs ([julie@cecol.net](mailto:julie@cecol.net))<sup>2</sup>, Donald E. Lyons  
([don.lyons@oregonstate.edu](mailto:don.lyons@oregonstate.edu))<sup>1</sup>, Daniel D. Roby  
([daniel.roby@oregonstate.edu](mailto:daniel.roby@oregonstate.edu))<sup>1</sup>, and Nathan H.  
Schumaker ([nathan.schumaker@gmail.com](mailto:nathan.schumaker@gmail.com))<sup>3</sup>

<sup>1</sup>Oregon Cooperative Fish and Wildlife Research Unit,  
Department of Fisheries and Wildlife, Oregon State  
University, Corvallis, Oregon, USA 97331

<sup>2</sup>Computational Ecology Group, Canmore, Alberta,  
Canada T1W 3L4

<sup>3</sup>Western Ecology Division, U.S. Environmental  
Protection Agency, Corvallis, Oregon, USA  
97331

\* Presenting author

Several of the largest breeding colonies of Caspian Terns (*Hydroprogne caspia*) in the Pacific Flyway of North America are now actively managed to reduce colony size and increase survival of juvenile salmonids in the Columbia River basin. To evaluate effects of prospective management options on future trends of the Flyway metapopulation of Caspian Terns, we developed a comprehensive, individual-based, stage-structured model using HexSim. The model incorporated a range of empirical data, including region-specific demographic parameters and dispersal rates estimated in a mark-resighting framework. A status quo management scenario projected an increasing Flyway population. When regional carrying capacity in the Flyway was reduced either singly or in combination to simulate prospective management actions, projected population size after 30 years was lower by 6-29% compared to the status quo scenario. A hypothetical elimination of the largest breeding colony in the Flyway, located in the Columbia River estuary, projected a persistent decline of the Flyway population, suggesting this one colony serves as an important source that sustains the entire Flyway-wide population. Projections from our model indicate resiliency of the Pacific Flyway population to a variety of prospective management options, but also suggest that the population is currently limited by the quantity and quality of nesting habitat available in the Pacific Flyway, and sustained by at least occasional high fledgling production by the colony in the Columbia River estuary. This robust model can serve as a valuable tool for resource managers in developing future adaptive management plans to meet long-term goals for conservation and management of the population.

## THE ALBATROSS DEMOGRAPHY PROGRAM: AN UPDATE

Roberta Swift (roberta\_swift@fws.gov)<sup>1</sup>, Bill Kendall (William.Kendall@colostate.edu)<sup>2</sup>, Beth Flint (beth\_flint@fws.gov)<sup>3</sup>, Bruce Peterjohn (bpeterjohn@usgs.gov)<sup>4</sup>, Matt Rogosky (mrogosky@usgs.gov)<sup>4</sup>, Jennifer McKay (jlmckay@hotmail.com)<sup>2</sup>, Kelly Goodale<sup>5</sup> (kelly\_goodale@fws.gov)<sup>5</sup>, Kim Uyehara (kim\_uyehara@fws.gov)<sup>6</sup>.

<sup>1</sup>U.S. Fish and Wildlife Service, MBHP, 911 NE 11<sup>th</sup> Ave, Portland, OR 97232

<sup>2</sup>Colorado State University, 1484 Campus Delivery, Fort Collins, CO 80523-1484

<sup>3</sup>U.S. Fish and Wildlife Service, 300 Ala Moana Blvd. Suite 5-231, Honolulu, HI 96850

<sup>4</sup>USGS Patuxent Wildlife Research Center, 12100 Beech Forest Rd., Laurel, MD 20708

<sup>5</sup>Midway Atoll National Wildlife Refuge, 1082 Makepono Street, Honolulu, HI 96819

<sup>6</sup>3500 Kilauea Road; P.O. Box 1128, Kilauea, HI 96754

The Albatross Demography Program (ADP) is a long-term collaboration between U.S. Fish and Wildlife Service and U.S. Geological Survey. The ADP began in 2002 as a means for standardizing monitoring of Laysan and black-footed albatross populations in remote atolls of the Northwestern Hawaiian Islands, now designated as Papahānaumokuākea Marine National Monument. After assessment of historic data, the team developed a standardized protocol in 2005 to provide robust estimates of survival, breeding probability, and reproductive success. Data have been collected under this protocol since 2006 at Midway Atoll National Wildlife Refuge, Tern Island, Laysan Island, within the Hawaiian Islands National Wildlife Refuge and Kilauea Point National Wildlife Refuge on Kauai Island. Recent progress includes the addition and updating of 75,000 banding records into Bird Banding Lab's (BBL) database. We error-checked and incorporated more than 250,000 demography data records into a newly-designed BBL database. We trialed and deployed a field data entry system that reduced data entry time and error rates. We provided preliminary estimates of survivorship and breeding probabilities using partial data sets and a multi-state model. Survival tended to be higher for Laysan albatrosses than black-footed albatrosses at both sites. The probability of skipping breeding was higher for Laysan than black-footed albatross. Goals in the coming year include vetting the remaining data and to finalize analyses to elucidate patterns in demographic parameters between breeding populations over time,

and to inform future sampling schemes for albatross demography.

## EXPERIMENTAL EVIDENCE OF ACCUMULATION OF PLASTIC-DERIVED CHEMICALS INTO SEABIRDS' TISSUE

Kosuke Tanaka (kosuke.t0423@gmail.com)<sup>1</sup>, Yutaka Watanuki (ywata@fish.hokudai.ac.jp)<sup>2</sup>, Hideshige Takada (shige@cc.tuat.ac.jp)<sup>3\*</sup>, Yoshinori Ikenaka (y\_ikenaka@vetmed.hokudai.ac.jp)<sup>1</sup>, Shouta M.M. Nakayama (shoutanakayama0219@gmail.com)<sup>1</sup>, Rei Yamashita (reiy@cc.tuat.ac.jp)<sup>3</sup>, Mayumi Ishizuka (ishizum@vetmed.hokudai.ac.jp)<sup>1</sup>

<sup>1</sup>Hokkaido University, Kita18, Nishi9, Kita-ku, Sapporo, Hokkaido, Japan

<sup>2</sup>Hokkaido University, Hakodate, Japan

<sup>3</sup>Tokyo University of Agriculture and Technology, Fuchu, Tokyo, Japan

\*Corresponding Author

Ingestion of marine plastic debris by seabirds has been globally observed. Marine plastics contain anthropogenic chemicals which are applied as additives and also absorbed from seawater. The assessment of the impacts of plastic-derived chemicals to seabirds who ingest plastics is needed. Accumulation of chemical additives from plastics to seabirds' tissue has been indicated by some previous studies, which analyzed polybrominated diphenyl ethers (PBDEs), one kind of flame retardants, in wild seabirds' tissues and ingested plastics. In addition, many additives other than PBDEs, such as UV absorbers, flame retardants, and anti-oxidants were detected by comprehensive analysis of chemicals in plastics found in seabirds' stomach. These chemicals can be exposed to seabirds in the same way as PBDEs. Because some of them are known to have toxic effects, e.g. endocrine disruption, on animals, there is concern about exposure risks to seabirds. To assess the exposure of chemicals from ingested plastics to seabirds in the environment, it is important to determine the transfer rate and accumulated concentration after plastic ingestion experimentally. In addition, to assess toxic risks caused by plastic ingestion, toxicological test is definitely necessary. For these reasons, administration experiment using chicks of streaked shearwater (*Calonectris leucomelas*) was conducted. Plastic pellets applied 5 kinds of additives were administered to the birds. The results of the chemical analysis and toxicological analysis will be presented at the conference.

STATUS AND NEST SURVIVAL OF ALEUTIAN AND  
ARCTIC TERNS BREEDING IN THE KODIAK  
ARCHIPELAGO, 2016-2018

Also alphabetized as Corcoran

Jill E. Tengeres<sup>1</sup> (jill.tengeres@oregonstate.edu),  
Robin M. Corcoran<sup>2</sup>, and Donald E. Lyons<sup>3</sup>  
(dlyons@audubon.org)

<sup>1</sup>Department of Fisheries and Wildlife, Oregon State  
University, 104 Nash Hall, Corvallis, OR.

<sup>2</sup>U.S. Fish and Wildlife Service, Kodiak National  
Wildlife Refuge, 1390 Buskin River Rd., Kodiak, AK.

<sup>3</sup>National Audubon Society Seabird Restoration  
Program and Department of Fisheries and Wildlife,  
Oregon State University, 104 Nash Hall, Corvallis, OR.

Aleutian terns (*Onychoprion aleuticus*) are colonial nesting seabirds that breed in coastal Alaska and the Russian Far East, often in association with Arctic terns (*Sterna paradisaea*). Tern colonies in the Kodiak Archipelago have been the focus of periodic monitoring and research since the 1970s, providing valuable information on the status and ecology of both species. Seabird colony records from the 1970s-2018 identify 53 sites in the Archipelago with a history of tern nesting. During the 2016-2018 breeding seasons we surveyed for terns at all 53 colony sites and searched for new colonies. Across the three breeding seasons, Arctic terns were active at 28 colonies, and Aleutian terns were observed at 12 colonies. We monitored nest survival through hatch by placing digital game cameras at 68 Aleutian tern nests at seven colonies, and 11 Arctic tern nests at five colonies. Only seven camera nests survived to hatch (six Aleutian tern and one Arctic tern nest), and to our knowledge none of these nests successfully fledged chicks. Predation was the leading cause of nest failure, followed by nest abandonment, often associated with flooding of nests at the high tide. Red fox were the most common nest predator for both tern species, but the nest predator assemblage was diverse and included glaucous-winged gulls, mew gulls, black-billed magpies, northwestern crows, brown bears, and short-tailed weasels. Due to high predation rates, variable nest initiation dates and re-nesting propensity, and frequent colony abandonment it was challenging to confirm nesting or determine nest success despite camera deployment and multiple visits to most colonies each season

PASSIVE MONITORING TO INVESTIGATE PREDATION  
PRESSURE AT ALEUTIAN TERN COLONIES IN  
COASTAL ALASKA

Jill E. Tengeres (jill.tengeres@oregonstate.edu),  
Donald E. Lyons (don.lyons@oregonstate.edu), Robin  
M. Corcoran (robin\_corcoran@fws.gov), Matthew  
McKown  
(matthew.mckown@conservationmetrics.com), and  
Kelly Nesvacil (kelly.nesvacil@alaska.gov)

<sup>1</sup>Department of Fisheries and Wildlife, Oregon State  
University, 104 Nash Hall, Corvallis, OR.

<sup>2</sup>U.S. Fish and Wildlife Service, Kodiak National  
Wildlife Refuge, 1390 Buskin River Rd., Kodiak, AK.

<sup>3</sup>Conservation Metrics, Inc., 145 McAllister Way, Santa  
Cruz, CA.

<sup>4</sup>Alaska Department of Fish and Game, Threatened,  
Endangered, and Diversity Program, 1255 West 8<sup>th</sup>  
Street, Juneau, AK.

Trend analyses indicate that the Alaskan population of Aleutian terns (*Onychoprion aleuticus*) has declined by more than 80% at known colonies over the past three decades, and the causes for this decline remain unknown. Due to isolated nesting locations, multiple visits to colonies over the nesting season are often unfeasible. Because of this, standard methods used to monitor other species of nesting terns are not applicable. During the 2018 nesting season, we employed multiple passive monitoring technologies, including acoustic recording devices and game cameras, to remotely monitor Aleutian tern colonies across the Kodiak Archipelago. We deployed passive acoustic recording units at 11 colony sites, for a total of 657 recording days. The acoustic units were programed to record for one minute out of every 6 minutes for the duration of the deployment period. At seven of the 11 acoustically monitored colonies, we also placed game cameras at a total of 44 Aleutian tern nests. Three colonies with both acoustic units and nest cameras also had game cameras mounted above vegetation height for a colony-wide view. The hatching success of nests was extremely low, due largely to predation by red foxes (*Vulpes vulpes*), brown bears (*Ursus arctos middendorffi*), northwestern crows (*Corvus caurinus*), black-billed magpies (*Pica hudsonia*), and glaucous-winged gulls (*Larus glaucescens*). By pairing game cameras with acoustic recorders, we seek to develop acoustic markers of predator disturbance (e.g., prolonged and/or elevated alarm calling) that can be applied broadly at colonies monitored solely with acoustic devices.

## JELLY BELLIES: WHY DO MARINE ENDOTHERMS EAT JELLYFISH?

Jean-Baptiste Thiebot\*<sup>1</sup> (jbthiebot@gmail.com) and  
Julie C. McInnes<sup>2</sup> (julie.mcinnnes@aad.gov.au)

<sup>1</sup>National Institute of Polar Research, 10-3 Midori-cho,  
Tachikawa, 190-8518 Tokyo, Japan

<sup>2</sup>Australian Antarctic Division, 203 Channel Highway,  
Kingston, TAS 7050, Australia

\*Presenter

There is growing evidence that gelatinous zooplankton (“jellies”) are a regular prey for a wide array of marine endotherms including seabirds. This interaction has been documented across the world’s oceans and using varied techniques. Consumption of jellies is intriguing in terms of energy reward, given endotherms have relatively high energy demands and jellies would provide little energy as prey. Here we show that many of the intuitive hypotheses commonly raised to explain predation on jellies have already been tested and most of them are unsupported. We emphasize that jellies are generally a non-anomalous prey (i.e., not reflecting a collapse in the trophic webs), and propose that they might be beneficial to marine endotherms for non-energetic reasons, such as enhancing physiological processes. Changing the “junk-food” hypothesis for a “green tea” framework may thus allow to better understand the widespread predation on jellies, although further biochemical analyses are needed to clarify this point.

## MULTI-YEAR TRACKING FROM TWO COLONIES HIGHLIGHTS KEY MARINE HABITATS FOR THE CONSERVATION OF RHINOCEROS AUKLETS (*CERORHINCA MONOCERATA*)

Jean-Baptiste Thiebot\*<sup>1</sup> (jbthiebot@gmail.com),  
Akinori Takahashi<sup>1</sup> (atak@nipr.ac.jp), Ui  
Shimabukuro<sup>1</sup> (shimabukuro.ui@nipr.ac.jp), Nobuo  
Kokubun<sup>1</sup> (kokubun@nipr.ac.jp) and Yutaka  
Watanuki<sup>2</sup> (ywata@fish.hokudai.ac.jp),

<sup>1</sup>National Institute of Polar Research, 10-3 Midori-cho,  
Tachikawa, 190-8518 Tokyo, Japan

<sup>2</sup>Graduate School of Fisheries Sciences, Hokkaido  
University, Minato-cho 3-1-1, Hakodate, 041-8611  
Hokkaido, Japan

In long-lived organisms, population dynamics are affected by survival over the non-breeding period

(often winter). The conservation of key wintering habitats, which are essential in supplying food and suitable wintering conditions, is thus expected to benefit to these populations. However, it is required to examine repeatability in these habitats’ use, both among years and populations, to assess whether these areas are important indeed for the conservation of the species. In this study, we used light-based geolocation loggers to track rhinoceros auklets (*Cerorhinca monocerata*) during their annual migration, from Teuri Island (Sea of Japan) across seven years, and from Daikoku Island (western Pacific) across three years. We examined spatial overlap in the core areas used by the birds across years and colonies. Finally, we built a predictive model of habitat suitability to evaluate whether other areas could also be suitable for the birds. We found a remarkable spatial consistency in the auklets’ wintering distribution across years: in the Sea of Okhotsk (in autumn), then in the southern Sea of Japan (in winter). Moreover, the two populations had similar at-sea distribution core areas. Modelled habitat suitability suggested that there was no other major suitable area for the birds in their flying range. In conclusion, our study shows that these areas are important because they are consistently used by rhinoceros auklets, across years and populations. Considering the globally significant bird numbers in this region and the threats to these birds there, we provide the scientific basis to flag these areas as important for the conservation of rhinoceros auklets.

## NO FLUFFY CAKES: ST. LAWRENCE ISLAND SEABIRDS RESPOND TO HISTORIC LOW WINTER SEA ICE Alphabetized by Thiebot and also alphabetized by Will

Alexis Will<sup>1,3</sup> (awill4@alaska.edu), Jean-Baptiste  
Thiebot\*<sup>1</sup> (jbthiebot@gmail.com), Aqef Waghiyi<sup>2</sup>  
(awill4@alaska.edu), Michael Toolie<sup>2</sup>  
(awill4@alaska.edu), Punguk Shoogukwruk<sup>2</sup>  
(awill4@alaska.edu), Akinori Takahashi<sup>1</sup>  
(atak@nipr.ac.jp), Alexander Kitaysky<sup>3</sup>  
(askitaysky@alaska.edu)

<sup>1</sup>National Institute of Polar Research, Tokyo, Japan

<sup>2</sup>Savoonga, Alaska

<sup>3</sup>Institute of Arctic Biology, University of Alaska  
Fairbanks, Fairbanks, Alaska

\*Presenter

By April 29<sup>th</sup>, 2018 sea ice was completely absent from the Bering Strait, marking an unusually early start to spring marine primary production in the region. Such

a sudden transition from a system with ice in the spring to one without any ice provides an opportunity to examine the responses of Arctic species to severe environmental perturbations and to understand how those changes may affect culturally significant food resources of Arctic communities. We studied the reproductive success, diet, and physiological state of five migratory seabird species that breed on St. Lawrence Island in 2016-2018, and in 2018 surveyed egg harvesters to measure the impact ocean conditions had on murre egg collection. The responses of these species to ocean conditions in 2018 encompassed a spectrum from a mass mortality event (thick-billed murres, *Uria lomvia*), to wide-spread reproductive failure (least and crested auklets, *Aethia pusilla* and *A. cristatella*), to less affected (black-legged kittiwakes, *Rissa tridactyla*). Murre eggs are of particular importance to the community of Savoonga, Alaska. Reports from this past summer suggest that murre egg harvests were 1/10<sup>th</sup> or lower than what is normally collected. Here we discuss the insights these seabird species provide on what ecosystem changes may have occurred in the wake of a winter with historically low concentrations of sea ice, and highlight how sudden changes in seabird reproduction can immediately affect local communities.

#### A COMPARISON OF THE ISOTOPIC NICHES OF TWO ALCIDS OVER ~1500 YEARS OF CHANGE IN THE CALIFORNIA CURRENT

Sarah K. Thomsen<sup>1</sup> (thomsesa@oregonstate.edu); Paul W. Collins<sup>2</sup> (pcollins@sbnature2.org), René L. Vellanoweth<sup>3</sup> (rvellan@calstatela.edu), Amira F. Ainis<sup>4</sup> (aainis@uoregon.edu), Jessica Rodriguez<sup>3</sup> (zeugirdor.jessica@gmail.com), Santos Cenicer<sup>3</sup> (santoscenicer@gmail.com), Tara Smiley<sup>5</sup> (tmsmiley@iu.edu), Jen Cotton<sup>6</sup> (jen.cotton@csun.edu), & Rebecca Terry (terryr@oregonstate.edu)<sup>1</sup>

<sup>1</sup> Department of Integrative Biology, Oregon State University

<sup>2</sup> Department of Vertebrate Zoology, Santa Barbara Museum of Natural History

<sup>3</sup> Department of Anthropology, California State University, Los Angeles

<sup>4</sup> Department of Anthropology and Museum of Natural and Cultural History, University of Oregon, Eugene

<sup>5</sup> Earth & Atmospheric Sciences, Indiana University

<sup>6</sup> Department of Geological Sciences, California State University Northridge

Seabirds on islands in the California Current are often heralded as indicators of ocean climate variability. However, far less is known about the responses of seabirds at time scales of hundreds to thousands of years. Near the southern end of the California Current in the Channel Islands National Park, two small nocturnal alcids breed on Santa Barbara Island. This includes the zooplanktivorous Cassin's Auklet (*Ptychoramphus aleuticus*) as well as the more generalist Scripps's Murrelet (*Synthliboramphus scrippsi*). Adults of both seabirds are consumed by Barn Owls (*Tyto alba*), and one particular owl roost in a sea cave contains a record of accumulated prey bones spanning at least the last ~1500 years. As part of a larger ongoing project detailing the faunal remains from the cave, we compared the isotopic niche dynamics for auklets and murrelets over the last millennium. We used stratigraphy and AMS <sup>14</sup>C dated samples to determine ages of the seabird bones and extracted bone collagen for stable isotope analysis ( $\delta^{13}\text{C}$  and  $\delta^{15}\text{N}$ ). We also compiled data on marine paleoclimate to determine how changing conditions may have affected niche dynamics and partitioning between the two alcids. We also evaluated the impacts of more recent historical changes to the island such as the introduction of non-native plants and animals and the advent of commercial fisheries. Finally, we discuss these findings in the context of ongoing climate change and implications for the future.

#### NOVEL METHODS DESCRIBE FINE-SCALE ALBATROSS-FISHERIES INTERACTIONS IN THE NORTH PACIFIC

Leigh G. Torres (leigh.torres@oregonstate.edu)\*, Rachael A. Orben (raorben@gmail.com)\*, Josh Adams (josh\_adams@usgs.gov)\*, Michelle Hester (michelle@oikonos.org)\*, Scott A. Shaffer (scott.shaffer@sjsu.edu)\*, Melinda Conners (connersm@gmail.com)\*, Kiyoaki Ozaki (ozaki@yamashina.or.jp)\*, Fumio Sato (sato@yamashina.or.jp)\*, Tomohiro Deguchi (deguchi@yamashina.or.jp)\*, Robert Suryan (rob.suryan@noaa.gov)\*, David Koordesma (david@globalfishingwatch.org)\*

<sup>1</sup> Geospatial Ecology of Marine Megafauna Lab (GEMM Lab), Oregon State University, Hatfield Marine Science Center, 2030 SE Marine Science Dr., Newport, OR 97365, USA,

<sup>2</sup> Department of Fisheries and Wildlife, Oregon State University, Hatfield Marine Science Center, 2030 SE Marine Science Dr., Newport, OR 97365, USA

<sup>3</sup> U.S. Geological Survey, Western Ecological Research Center, Santa Cruz Field Station, 2885 Mission St., Santa Cruz, CA 95060, USA

<sup>4</sup> Oikonos Ecosystem Knowledge, 41-202 Kalanianaʻole Hwy, Waimanalo, Hawai'i, 96795, USA,

<sup>5</sup> Department of Biological Sciences, San Jose State University, One Washington Square, San Jose, CA 95192-0100, USA

<sup>6</sup> Department of Interdisciplinary Arts and Sciences, University of Washington, Bothell Campus, 18115 Campus Way NE, Bothell WA, 98011 USA

<sup>7</sup> Division of Avian Conservation, Yamashina Institute for Ornithology, 115 Konoyama, Abiko, Chiba 270-11, Japan

<sup>8</sup> NOAA Fisheries, Alaska Fisheries Science Center, Auke Bay Laboratories, Ted Steven's Marine Research Institute, 17109 Pt. Lena Loop Rd., Juneau, Alaska 99801, USA

<sup>9</sup> Global Fishing Watch, Global Fishing Watch, Washington, DC 20036, USA

\*Presenting author

While seabird-fisheries overlap has been documented at many scales, identification of interaction events has lagged due to a lack of high resolution vessel movement data, particularly in the high-seas. Here, we develop methods that reveal North Pacific albatross-fisheries interactions. We compiled GPS tracks representing foraging trips conducted by Laysan (n=2,398 days; *Phoebastria immutabilis*) and black-footed (n=1,095 days; *P. nigripes*) albatrosses breeding in the Hawaiian islands, and juvenile short-tailed albatross (n=6,497 days; *P. albatrus*) from Japan. We developed methods to assess albatross movements associated with fishing vessel activity derived from Global Fishing Watch (GFW) data. GFW uses detection algorithms to process dense vessel-AIS datasets to identify commercial fishing operations. GFW provides vessel location, movements, fishing method, flag nation, and MMSI number (vessel ID). We identified overlap between bird and boat at daily and 80 km scales. We quantified encounter events at scales of 10 min and from 30 to 3 km based on the assumed distance at which birds are able to perceive a boat, and interaction events when associations were <3 km. Short-tailed albatross had the most overlap, encounter, and interaction locations (n=11,464; n=4,552; n=1,161, respectively) relative to Laysan (n=246; n=69; n=27, respectively) and black-footed (n=68; n=31; n=15, respectively) albatrosses. However, black-footed (48%) and Laysan (39%) albatrosses had greater interaction rates (interactions ÷ encounters) than short-tailed albatrosses (26%). Multivariate modeling, including albatross species, fishing vessel method and flag, and temporal and

environmental variables, are used to describe drivers of albatross interaction events and distance between bird and boat.

## LASERS, DIVERTERS AND POWER LINE REMOVALS: COST EFFECTIVE SOLUTIONS TO KAUAI'S SEABIRD POWER LINE MORTALITY CRISIS

Marc Travers<sup>1</sup> (marc.s.travers@gmail.com), Adam Elzinga<sup>2</sup> (adamelzinga@gmail.com), M. Tim Tinker<sup>2,3</sup> (ttinker@nhydra.com), Scott Driskill<sup>4</sup> (spdriskill@gmail.com), Matthew McKown<sup>5</sup> (matthew.mckown@conservationmetrics.com), Theresa Geelhoed<sup>6</sup> (geelhoed.theresa@gmail.com), André F. Raine<sup>7</sup> (araine6@hawaii.edu)

<sup>1</sup> Kauai Endangered Seabird Recovery Project, 3900 Hanapepe Rd, Hanapepe, Kaua'i, HI 967162

<sup>2</sup> Nhydra Ecological Research, 11 Parklea Dr, Head of St Margarets Bay, Nova Scotia, B3Z 2G6

<sup>3</sup> Conservation Metrics Inc. 145 McAllister Way, Santa Cruz, CA 95060

\*Presenter & Corresponding author: email – marc.s.travers@gmail.com

Seabird mortality from power line collisions on Kauai has significantly contributed to the massive historical decline of both Newell's Shearwater *Puffinus newelli* and Hawaiian Petrels *Pterodroma sandwichensis* (94 and 78% respectively) and continues to suppress their populations. This problem has been documented since 1994. Work undertaken by the Kauai Endangered Seabird Recovery Project (KESRP) has shown that there are an estimated 10,552 seabird power line collisions annually, resulting in a minimum of 981-1600 dead adult Newell's Shearwaters and Hawaiian Petrels each year. While undergrounding power lines is the only way to ensure zero collisions, this is costly. We therefore examine readily available alternatives and provide an estimated reduction in mortality if these methods were to be deployed at key areas. To study efficacy we use data from observations of birds (>5000 hours) at power lines and our Acoustic Strike Monitoring system (>300,000 hours). We report on the efficacy of the Wildlife Laser Fence (a novel technology developed and tested by KESRP) and two types of bird diverters (reflective and LED). We fit a mechanistic model of seabird collisions to observational data, incorporating powerline characteristics as well as spatial, temporal, and environmental covariates, and use this to assess the conservation benefit of removing non-essential wires

and lowering wires. With a combination of all solutions we show that the impact of power lines on endangered seabirds can be minimized to manageable levels rapidly by these cost-effective methods and should be considered a priority conservation measure.

#### HABITAT RESTORATION FOR SEABIRDS AND NATIVE HAWAIIAN SPECIES AT HO'OKIPA – MAUI

Karla Trigueros (ktrigueros@csumb.edu)<sup>1</sup>, Martin Frye (mfrye@hawaii.edu)<sup>1</sup>, Jennifer Learned (jlearnedj@hawaii.edu)<sup>1</sup>, Jay Penniman (jayfp@hawaii.edu)<sup>1</sup>

<sup>1</sup> Maui Nui Seabird Recovery Project, P.O. Box 903, Makawao, Hawai'i 96768

Although their distribution is widespread, development and introduction of invasive species has impacted the 'ua'u kani (wedge-tailed shearwater; *Ardenna pacifica*), leaving the main Hawaiian Islands with remnant populations. Ecological restoration at Ho'okipa is a continuous effort aiming to protect the 'ua'u kani colony, prevent erosion and reef degradation, provide future nesting habitat for seabirds displaced by sea-level rise, and also to support endangered Hawaiian yellow-faced bees (*Hyleaus* species). Fifteen years of 'ua'u kani colony data demonstrate that the Ho'okipa colony is static, and suffers from predation and trampling. An ungulate exclusion fence, built in 2017, has assisted in the protection of the colony. Continued tracking will determine how restoration enhances the population.

With the support of numerous organizations and volunteers, this is a community based effort in the regeneration of coastal strand vegetation. Project goals include extensive weeding, cultivation and outplanting of native plants such as Kāwelū (*Eragrostis variabilis*) and 'Aki' aki (*Sporobolus virginicus*).

Annual vegetation community assessments demonstrate regeneration of the native plant community. With continued success, this restoration project will be used as a template as we work to identify potential areas for future seabird habitat that will be critical as they lose breeding habitat elsewhere to sea-level rise. Seabirds have an important role in the ecosystem as vectors for sea-derived nutrients and Hawaiian yellow-faced bees pollinate native Hawaiian plants. By protecting the populations through restoration and management of

habitat the populations will have the capability to thrive and provide ecosystem functions.

#### RAT AND FERAL CAT DIETARY SPECIALIZATION ON ENDANGERED SEABIRDS: IMPLICATIONS FOR PROTECTING SEABIRD POPULATIONS ON KAUA'I

Ryan John Trimbath (rjt34@zips.uakron.edu)<sup>1</sup>, Dr. Anne Wiley (awiley@uakron.edu)<sup>1</sup>, Megan Munyon (mm243@zips.uakron.edu)<sup>1</sup>, Kyle Pias (kpias@hawaii.edu)<sup>2</sup>, Alex Dutcher (dutcher.alex@gmail.com)<sup>2</sup>, Galen Reid (togalen@gmail.com)<sup>2</sup> and Dr. Andre Raine (araine6@hawaii.edu)<sup>3</sup>

<sup>1</sup>University of Akron, Department of Biology, Akron, OH USA 44333

<sup>2</sup>Hono O Nā Pali Seabird Mitigation Project, 1544 Haleukana St, Lihue, HI USA 96716

<sup>3</sup>University of Hawaii - Pacific Cooperative Studies Unit, Department of Land and Natural Resources, Division of Forestry and Wildlife, 3060 Eiwa Street, Room 306, Lihue, HI USA 96766

<sup>4</sup>Kaua'i Endangered Seabird Recovery Project, 3900 Hanapepe Rd Hanapepe, HI USA 96716

Invasive rats (*Rattus spp.*) and cats (*Felis catus*) are a major contributor to global seabird decline, particularly on islands. Although total eradication is preferred, predator control within seabird colonies has successfully reduced predation on endangered seabirds on Kaua'i and other islands. Both cats and rats can show dietary specialization and if a subset of cats or rats specialize on seabirds, targeted removal of these individuals could be a viable strategy to protect seabird colonies. Our research uses stable isotopes to identify and quantify the prevalence of specialization by cats and rats on Hawaiian Petrels (*Pterodroma sandwichensis*) and Newell's Shearwater (*Puffinus newelli*) nesting in the mountains of the Hono O Nā Pali Natural Area Reserve in Kaua'i. Stable isotope ratios differ predictably between terrestrial and marine food webs, such that significant consumption of seabirds should result in increased  $\delta^{15}\text{N}$ ,  $\delta^{13}\text{C}$ , and  $\delta^{34}\text{S}$  in predator tissues. In Black Rats (*Rattus rattus*) (n>75), we observed a seasonal shift of isotope values during the nesting season, suggesting a dietary shift to incorporate more marine-derived nutrients (presumably, seabirds). However, stable isotope mixing models suggest that at a population-level, it is rare for rats to obtain >50% of their diet from seabirds. In contrast, stomach content and video evidence suggest that individual cats on Kaua'i can become



seabird-specialists. We analyzed serial samples from cat whiskers (n>30) to determine the prevalence of seabird specialization through a 10-week period. Our isotope data suggest that seabirds are a significant diet item of a subset of Kaua'i rats and cats and highlights the need to detail the ecology of these invasive predators.

#### QUANTIFYING THE ABUNDANCE AND IDENTITY OF MICROPLASTICS IN BREEDING BIRDS OF THE BERING SEA

Jannelle Trowbridge\* ([jtrowbridge@alaska.edu](mailto:jtrowbridge@alaska.edu))<sup>1</sup>,  
Veronica Padula ([ympadula@alaska.edu](mailto:ympadula@alaska.edu))<sup>1,2</sup>, and Dr.  
Douglas Causey ([dcausey@alaska.edu](mailto:dcausey@alaska.edu))<sup>1,2</sup>

<sup>1</sup>University of Alaska Anchorage, UAA Biological Sciences, 3211 Providence Drive, Anchorage, AK, 99508, United States

<sup>2</sup>University of Alaska Fairbanks, 505 South Chandalar Drive, Fairbanks, AK 99775

Plastic fragments are found in all terrestrial, freshwater, and marine ecosystems, extending from the Arctic to Antarctica. A variety of animals including fish, seabirds, turtles, and marine mammals get entangled in plastics or ingest them. In the case of seabirds, they mistake plastic for prey items, or as food to give to their chicks. Ingestion can result in ulcerations, starvation, or death.

The most problematic is what we cannot see: the "microplastics." Plastics degrade through exposure to sunlight and the ocean, and quickly become microscopic. The microplastics act as sponges and absorb numerous chemical contaminants, particularly endocrine-disrupting compounds like phthalates, PCBs, and other persistent organic pollutants (POPs). Microplastics can pass through a bird's stomach and intestine, where chemicals leach off these particles and get incorporated into the animal's tissue. These effects may be exacerbated in humans through personal and subsistence harvest of these marine organisms, particularly of top-level members of the coastal food web, such as salmon and egg harvests.

The majority of studies that have examined microplastics and nanoplastics have identified them visually, either by eye or under a microscope. The problem with identifying microplastics only visually is multifold. Many microplastics, especially in sediment, are covered in a biofilm and resemble biotic material, and can thus be underestimated when being visually sorted. We report here the further results of using

advanced UV and IR autofluorescence techniques to characterize the composition and abundance of microplastics in stomach samples and body tissues. We also test the significance of the type of plastics and their association with detectable presence of immunocompromising chemicals.

#### COLONIAL WATERBIRD MONITORING USING UAS IN THE COLUMBIA RIVER BASIN

Aaron Turecek ([aaron@realtimeresearch.com](mailto:aaron@realtimeresearch.com))<sup>1</sup>,  
James Tennyson ([james@realtimeresearch.com](mailto:james@realtimeresearch.com))<sup>1</sup>, Ken  
Collis ([Ken@realtimeresearch.com](mailto:Ken@realtimeresearch.com))<sup>1</sup>, Brad Cramer  
([brad@realtimeresearch.com](mailto:brad@realtimeresearch.com))<sup>1</sup>, Pete Loschl  
([pete.loschl@oregonstate.edu](mailto:pete.loschl@oregonstate.edu))<sup>2</sup>

<sup>1</sup>Real Time Research, 1000 SW Emkay Dr., Bend, OR 97702

<sup>2</sup>Oregon State University, 104 Nash Hall, Corvallis, OR 97331-3803

The recent and rapid advancement of cost-effective and reliable small unmanned aircraft platforms and sensors, along with the 2016 modernization of the governance of unmanned aircraft systems (UAS) in the national airspace, has led to a boon in UAS use in a wide range of applications. Following a 2016 pilot study, we replaced our manned aerial photography surveys with unmanned surveys in 2017 and 2018, surveying 14 bird species at 18 sites across the Columbia River Basin and San Francisco Bay, totaling nearly 100 missions. The primary target species surveyed were double-crested cormorants (*Phalacrocorax auritus*), Brandt's cormorants (*Phalacrocorax penicillatus*), Caspian terns (*Hydroprogne caspia*), California gulls (*Larus californicus*), ring-billed gulls (*Larus delawarensis*), and American white pelicans (*Pelecanus erythrorhynchos*). The benefits gained from using UAS platforms are numerous, including cost savings, mission and method flexibility, image quality, and workflow expedience. The greater image resolution achieved with UAS's compared to manned survey flights has improved our ability to leverage object-based classification tools to automate feature extraction to quickly and accurately derive bird counts and other colony metrics while reducing manual image interpretation time. As UAS technology and machine learning methods continue to evolve, our ability to quickly and accurately survey, inventory, and analyze avian colonies will continue to progress. Additionally, as guidelines for the use of UAS in the national airspace expand to accommodate currently restricted flight characteristics like "beyond visual line of sight" flight, we will be able to extend the autonomy of these types

of surveys, and realize greater gains in human safety, further cost savings, and faster workflows from survey to analytical products.

#### TRANSLOCATION OF HAWAIIAN SEABIRDS TO HIGH ISLANDS TO MITIGATE THE EFFECTS OF CLIMATE CHANGE

Eric A. VanderWerf<sup>1</sup> ([eric@pacificrimconservation.org](mailto:eric@pacificrimconservation.org)), Lindsay C. Young, C. Robby Kohley, Megan Dalton<sup>1</sup>, Leilani Fowlke<sup>1</sup>, Sarah Donahue<sup>1</sup> and Erika Dittmar<sup>1</sup>

<sup>1</sup> Pacific Rim Conservation, P.O. Box 61827, Honolulu, HI 96839, USA

\*presenting author

The majority of the worldwide populations of Laysan and Black-footed Albatrosses (LAAL and BFAL), Bonin Petrels (BOPE) and Tristram's Storm-Petrels (TRSP) nest on low-lying atolls in the Northwestern Hawaiian Islands (NWHI) that are threatened by sea level rise. Establishing new colonies on higher islands is among the highest priority conservation actions for these species. From 2015- 2018, we translocated 50 LAAL, 50 BFAL, 53 BOPE and 25 TRSP chicks from the NWHI and 50 LAAL from Kauai to James Campbell National Wildlife Refuge on Oahu. The birds were placed in a 16-acre predator exclusion fence where a team of biologists raised them on a diet of fish and squid slurry, and closely monitored their health and growth. Fledging success was 95% (169/178) overall; 92% for LAAL, 90% for BFAL, and 100% for BOPE and TRSP. Three years of LAAL translocations took place from 2015-2017. 2018 was the second year of BFAL translocations and the first year of BOPE and TRSP translocations. Due to their high natal philopatry, we expect the translocated chicks to begin returning to the release site in 3-5 years and to start nesting there in 5-8 years. One chick translocated in 2015 returned in 2018. We also employed social attraction for each species using decoys and/or a sound system. The number of wild adult LAAL visiting the refuge increased each year, with a peak of 348 visits in 2018 and up to 13 adults present simultaneously. A pair of wild LAAL nested on the refuge in 2018. No wild adult BFAL, BOPE, or TRSP visited. The methods we are developing for translocating and rearing seabirds will be useful for similar projects involving other species.

#### WHAT DO LARGE SCALE REGIME SHIFTS IN THE NORTH ATLANTIC MEAN FOR ICELANDIC SEABIRDS?

Freydis Vigfusdottir ([freidisv@hi.is](mailto:freidisv@hi.is))

University of Iceland, Gimli – Sæmundargata 10, 101 Reykjavik, Iceland

The Northeast Atlantic is strongly affected by climate change, and shifts in abundance and distribution of many organisms has been observed including northward range shift of many fish species and changes in euphausiid abundance. Increasing frequency of widespread seabird breeding failure and population decline is evident. Seabirds are of special value for their status as higher predators: demographic changes reflect impacts in ecosystems, making them indicators of changes to marine resources. Iceland supports a large proportion of North Atlantic breeding seabirds and, while surveys of Icelandic seabird abundance and demography are limited, some data exists, mostly in grey literature, revealing declines in several species. Here we present an overview of recent research on Icelandic marine environment, in relation to a review of Icelandic seabird data available to date. At least 10 seabird species South and West of Iceland experienced particularly poor breeding success, but some studies indicated better success in the North. However, most recent case studies indicate a worsening situation in the North during a period of northward movement of main prey after a displacement of the polar sea front. Although, particularly one species has benefitted from influx of new southerly fish species in Icelandic waters, available information for 24 species show that the most important prey species overall was sandeel and then capelin in the North. Icelandic capelin and sandeel stocks have been at low levels for over a decade and as long as that situation persists, poor performance of most Icelandic seabird species is expected.

#### PRELIMINARY FINDINGS ON THE DIET OF LAYSAN ALBATROSSES, *PHOEBASTRIA IMMUTABILIS*, IN THE EASTERN BERING SEA AND ALEUTIAN ISLANDS REGION

Also alphabetized by Fitzgerald

William A. Walker ([mindwalk@msn.com](mailto:mindwalk@msn.com))<sup>1</sup>, Shannon Fitzgerald ([shannon.fitzgerald@noaa.gov](mailto:shannon.fitzgerald@noaa.gov))<sup>2</sup>, Jessie Beck ([jessie@oikonos.org](mailto:jessie@oikonos.org))<sup>3</sup>, and Erica L. Donnelly-Greenan ([donnellygreenan@gmail.com](mailto:donnellygreenan@gmail.com))<sup>3</sup>

<sup>1</sup>Marine Mammal Laboratory, Alaska Fisheries Science Center, NMFS, NOAA.

<sup>2</sup> Resource Ecology and Management Division, Alaska Fisheries Science Center, NMFS, NOAA.

<sup>3</sup> Oikonos Ecosystem Knowledge, Santa Cruz, CA.

Stomach contents were analyzed from 125 Laysan albatrosses, *Phoebastria immutabilis*, collected from the fisheries bycatch in the eastern Bering Sea and Aleutian Islands region during the years 2008 – 2017. Food items obtained from fisheries sources and from the natural environment were readily identifiable and are treated separately in the analyses. Twenty species scavenged from fisheries sources were present in 92 samples with an overall frequency of occurrence (FO) of 89.0 %. Of these, three species utilized as bait in the demersal longline fisheries; Argentine short-fin squid, *Illex argentinus*, Pacific saury, *Cololabis saira*, and Pacific herring, *Clupea pallasii*, were the most common with an FO of 46.0 %. The remaining 16 species had a collective FO of 78.6 % and were scavenged from trawl fisheries bycatch discards (offal). Within the naturally occurring diet component there were 28 species present with an overall FO of 96.1 %. Twenty-five species of mesopelagic squid made up the bulk of the naturally occurring diet with an overall frequency by number of 99.0 % and FO of 96.1 %. Fishes played a minor role in the natural diet with a frequency by number of only 0.9 % with an FO of 4.0 %. Of the naturally occurring food components, *Taonius borealis* dominated the diet making up by number 43.5 % followed by ten species of the family Gonatidae with a 29.3 % contribution by number. Collectively they dominated the natural diet with a contribution of 72.8% by number and occurrence of 89.3%. We see a distinct bias toward adult-size mesopelagic squid, revealing these were probably scavenged at the surface as dead or moribund.

#### PREY SWITCHING AND CHANGE OF PRODUCTIVITY OF RHINOCEROS AUKLETS IN THE JAPAN SEA: LINK WITH DECADEAL CLIMATE REGIME SHIFT?

Yutaka Watanuki<sup>1</sup>, Mariko Yamamoto<sup>2</sup>, Jumpei Okado<sup>3</sup> and William Sydeman<sup>1</sup>

<sup>1</sup>Hokkaido University, Hakodate, Japan. E-mail: ywata@fish.hokudai.ac.jp

<sup>2</sup>Farallon Institute, Petaluma, CA, USA

Decadal climate regime shift is believed to induce the change of the dominant forage fish species (sardine vs anchovy for an example), a key component of marine ecosystem, and hence prompt responses of marine top

predators. We sampled the bill-loads for chicks and monitored the fledging success and growth of chicks of Rhinoceros Auklet *Cerorhinca monocerata* (RHAU) at Teuri Island, northern Japan Sea in 1984-1987 and 1992-2018. RHAU switched fish species in the bill-loads from the cold-water species (sardine *Sardinops melanostictus*, sandlance *Ammodytes personatus*) to warm-water species (Japanese anchovy *Engraulis japonicus*) and juvenile greenling *Pleurogrammus azonus* between 1988 and 1992, then switched to anchovy in 1997/1998 when the Pacific Decadal Oscillation (PDO) index changed to be negative and SST in the Japan Sea shifted to be warmer. In 2013/14 when PDO shifted to be positive, though SST in the Japan Sea did not show apparent shift, RHAU switched fish species to juvenile greenling and squids and decreased the chick productivity dramatically. In 2018 RHAU switched fish species to the cold-water species, though information of climate and fish stock is not currently available. Thus seabird could be a prompt and useful sentinel of the change of marine ecosystem that may be driven by decadal climate regime shift.

#### VARIATION IN PHENOLOGY AND REPRODUCTIVE SUCCESS OF THREE CORMORANT SPECIES IN CENTRAL OREGON

Makenzie Weber (webermak@oregonstate.edu)<sup>1,2</sup>, Christian Cortez (cucomitzi@gmail.com)<sup>2,3</sup>, Jane Dolliver (jane.dolliver@oregonstate.edu)<sup>1,2</sup>, Rachael Orben (rachael.orben@oregonstate.edu)<sup>1,2</sup>, Don Lyons (don.lyons@oregonstate.edu)<sup>1,2</sup>

<sup>1</sup>Department of Fisheries and Wildlife, Oregon State University, 104 Nash Hall, Corvallis, OR 97331

<sup>2</sup>Hatfield Marine Science Center, Oregon State University, 2050 Marine Science Drive, Newport, OR 97365.

<sup>3</sup>Yaquina Head Outstanding Natural Area, Bureau of Land Management, 750 NW Lighthouse Drive Newport, OR 97365.

Wildlife populations are often strongly influenced by breeding habitat conditions and human activity. On the Oregon coast, we are interested in how these factors may influence nesting seabirds. The Yaquina Head Outstanding Natural Area mixed-species cormorant colony has been monitored since 2008. In 2018, we added two additional sites, Pirate Cove and the Yaquina Bay Bridge to better understand how habitat, disturbance from predators, and human activities may influence phenology (the timing of breeding stages like egg laying and chick hatching) and nesting success (as

measured by maximum chicks viewed per nest). Using a spotting scope, we recorded the contents of visible nests from standardized viewing platforms weekly, June through August 2018. By making these observations across the breeding season, we can quantify both the phenology and success of individual nests. The resulting dataset includes 483 nests of three species; 259 Brandt's cormorant nests (*Phalacrocorax penicillatus*), 181 pelagic cormorant nests (*P. pelagicus*), and 43 double-crested cormorant nests (*P. auritus*). We found that the Yaquina Bay Bridge colony produced chicks significantly earlier than the Yaquina Head and Pirate Cove colonies. Cormorants at the Yaquina Head colony also produced chicks significantly earlier than the Pirate Cove colony. Brandt's cormorants had significant differences in productivity across all three colonies. At the Yaquina Bay Bridge, there was a significant difference in the productivity of all three species present. Our findings indicate a possible relationship between phenology and latitude with colonies located further south hatching chicks significantly earlier than colonies to the north.

#### FORAGING BEHAVIOR AND REPRODUCTIVE SUCCESS OF BROWN BOOBIES (*SULA LEUCOGASTER*) ACROSS AN ENVIRONMENTAL GRADIENT

Anne Wiley (awiley@uakron.edu)<sup>1</sup>, Nathan Michael (npm19@uakron.edu)<sup>1</sup>, Roxanna Torres (lrrtorres@unam.mx)<sup>2</sup>, Andreanna Welch (a.j.welch@durham.ac.uk)<sup>3</sup>, Josh Adams (josh\_adams@usgs.gov)<sup>4</sup>, Jonathan Felis (jfelis@usgs.gov)<sup>4</sup>, Mario Erandi Bonillas-Monge (marioerandi@gmail.com)<sup>5</sup>, Samantha Hodgson (smh176@uakron.edu)<sup>1</sup>, Laura Lopez-Marquez (laura.angelica7@gmail.com)<sup>2</sup>, and Alejandro Martínez-Flores (laura.angelica7@gmail.com)<sup>2</sup>

<sup>1</sup>University of Akron, Auburn Science Center, 235 E Carroll St., Suite D401, Akron, OH USA 44325

<sup>2</sup>Universidad Nacional Autónoma de México, Laboratorio de Conducta Animal, Institute of Ecology, México City, México

<sup>3</sup>Durham University, Department of Biosciences, South Road, Durham, DH1 3LE, United Kingdom

<sup>4</sup>United States Geological Survey, Western Ecology Research Center, 2885 Mission Street, Santa Cruz, CA, USA 95060

\*presenting and corresponding author

Many seabird species forage across pronounced environmental gradients in productivity, sea surface temperature, and depth. Nevertheless, relatively little is known about how individual species adjust their

foraging behavior in contrasting environments, or if there are predictable fitness consequences to these adjustments. Here, we describe the foraging behavior and reproductive success of the pantropical brown booby (*Sula leucogaster*) along a gradient in productivity and oceanographic parameters along the west coast of Mexico. We tracked >200 incubating and chick-rearing individuals with iGotU GT-120 GPS loggers and used stable carbon and nitrogen isotope ratios from blood to further characterize diet and foraging location at three breeding colonies. Our results show considerable inter-colony variation in foraging behavior, including a large difference in maximum range between birds on San Pedro Mártir and those nesting on San Jorge and Islas Marietas (ca. 200 km vs. 100 km). Birds on San Pedro Mártir were also more likely to spend nights away from their breeding colony, with incubating males passing as many as 50% of their nights on the ocean or other islands. Our stable isotope data show variable contribution of benthic prey to brown booby diet and indicate that in some cases, the degree of inshore versus offshore foraging is predictive of reproductive success. Overall, our data revealed considerable intra-specific foraging variation. Advancing our understanding of such foraging variation and its link to fitness will provide valuable insights into the adaptability of seabirds and their ability to cope with environmental change.

#### NO FLUFFY CAKES: ST. LAWRENCE ISLAND SEABIRDS RESPOND TO HISTORIC LOW WINTER SEA ICE

Also alphabetized by Thiebot

Alexis Will<sup>1,2</sup> (awill4@alaska.edu), Jean-Baptiste Thiebot\*<sup>1</sup> (jbthiebot@gmail.com), Aqef Waghiyi<sup>2</sup> (awill4@alaska.edu), Michael Toolie<sup>2</sup> (awill4@alaska.edu), Punguk Shoogukwruk<sup>2</sup> (awill4@alaska.edu), Akinori Takahashi<sup>1</sup> (atak@nipr.ac.jp), Alexander Kitaysky<sup>3</sup> (askitaysky@alaska.edu)

<sup>1</sup>National Institute of Polar Research, Tokyo, Japan

<sup>2</sup>Savoonga, Alaska

<sup>3</sup>Institute of Arctic Biology, University of Alaska Fairbanks, Fairbanks, Alaska

\*Presenter

By April 29<sup>th</sup>, 2018 sea ice was completely absent from the Bering Strait, marking an unusually early start to spring marine primary production in the region. Such a sudden transition from a system with ice in the spring to one without any ice provides an opportunity

to examine the responses of Arctic species to severe environmental perturbations and to understand how those changes may affect culturally significant food resources of Arctic communities. We studied the reproductive success, diet, and physiological state of five migratory seabird species that breed on St. Lawrence Island in 2016-2018, and in 2018 surveyed egg harvesters to measure the impact ocean conditions had on murre egg collection. The responses of these species to ocean conditions in 2018 encompassed a spectrum from a mass mortality event (thick-billed murres, *Uria lomvia*), to wide-spread reproductive failure (least and crested auklets, *Aethia pusilla* and *A. cristatella*), to less affected (black-legged kittiwakes, *Rissa tridactyla*). Murre eggs are of particular importance to the community of Savoonga, Alaska. Reports from this past summer suggest that murre egg harvests were 1/10<sup>th</sup> or lower than what is normally collected. Here we discuss the insights these seabird species provide on what ecosystem changes may have occurred in the wake of a winter with historically low concentrations of sea ice, and highlight how sudden changes in seabird reproduction can immediately affect local communities.

#### ENDANGERED PERUVIAN DIVING-PETREL BREEDING POPULATION INCREASING DRAMATICALLY ON ITS MAIN BREEDING SITE IN CHILE

Coral Wolf (coral.wolf@islandconservation.org)<sup>1</sup>, Claudia Fernandez (claeferza@gmail.com)<sup>2</sup>, Matthew McKown (matthew.mckown@conservationmetrics.com)<sup>3</sup>, and Nick Holmes (nick.holmes@islandconservation.org)<sup>1</sup>

<sup>1</sup>Island Conservation, 2100 Delaware Ave St 1, Santa Cruz, CA 95060 USA

<sup>2</sup>Departamento de Biología Marina, Facultad de Ciencias del Mar, Universidad Católica del Norte, Larrondo 1281, Coquimbo, Chile

<sup>3</sup>Conservation Metrics, 145 McAllister Way, Coastal Science Campus, Santa Cruz, CA 95060 USA

The historically large population (~200,000 individuals) of Peruvian diving-petrels (*Pelecanoides garnotii*) has declined in the last century due to factors including guano extraction, over-exploitation of fisheries, the introduction of invasive predators, and the increasing frequency of El Niño events. The Peruvian diving-petrel, listed as Endangered by the IUCN and endemic to the Humboldt Current System, breeds on a subset of its original nesting islands in

Chile and Peru. In 2010 and 2016-18, we conducted surveys of all known diving petrel breeding colonies on Choros Island, estimated to host approximately 95% of the total diving petrel breeding population in Chile. We mapped the breeding area to determine colony size, estimated nest density and occupancy, and measured acoustic activity rates at colony and non-colony sites. All metrics increased significantly between 2010 and 2016-18, except acoustic activity (which showed a positive trend), indicating the breeding population on the island is growing – a likely result of factors including protection of the island, food availability, and a rabbit eradication completed in 2013. Future conservation efforts should include reestablishing a diving petrel breeding colony on nearby Chañaral Island.

#### LONG-TERM TRENDS, AND POTENTIAL DRIVERS OF CHICK DIET IN FOUR TERN SPECIES IN THE GULF OF MAINE, USA

Keenan Yakola (kyakola@umass.edu)<sup>1,2,3\*</sup>, Adrian Jordaan<sup>2</sup> (ajordaan@eco.umass.edu), Paula Shannon (pshannon@audubon.org)<sup>1</sup>, Stephen Kress (skress@audubon.org)<sup>1</sup>, & Michelle Staudinger<sup>2,3</sup> (mstaudinger@usgs.gov)

<sup>1</sup> National Audubon Society Seabird Restoration Program, 12 Audubon Road, Bremen, ME USA 04551

<sup>2</sup> Department of Environmental Conservation, University of Massachusetts Amherst, Amherst, MA USA 01003

<sup>3</sup> DOI Northeast Climate Adaptation Science Center, Amherst, MA USA 01003

The Gulf of Maine, USA is home to four colonial co-nesting tern species; the Least Tern (*Sterna antillarum*), Common Tern (*Sterna hirundo*), Arctic tern (*S. paradisaea*), and Roseate Tern (*S. dougallii*). As a relatively diverse taxonomic group, terns provide an ideal system to study ecological separation and overlap of sympatric species at local, regional, and broader geographic scales. Furthermore, terns are effective ecosystem sentinels, providing information on ecosystem productivity, forage fish availability, and young-of year recruitment in fisheries. Using over 30 years of chick provisioning data from seven different islands, we conducted a variety of multivariate analyses to evaluate variation in the provisioning habits among tern species and across nesting colonies. We explored potential climatic and biotic drivers of the long-term trends in major prey species using generalized linear mixed models. Significant

differences in diet were found among tern species and intraspecific variation was detected across islands. Despite spatial differences in provisioning, three prey species- hake (*Urophycis sp.*), herring (*Clupea sp.*), and sand lance (*Ammodytes sp.*) - comprised the majority (48-74%) of chick diet across all island-tern species combinations. In addition, both broad-scale and local climatic conditions, including the position of the Gulf Stream current and seasonal oceanographic parameters, played an important role in determining the relative contributions of prey species in tern chick diets. Our results improve the understanding of tern's vulnerability to climate change through foraging plasticity, and provide needed information to guide conservation and ecosystem-based fisheries management in the Gulf of Maine.

#### OCCURRENCE OF WIDE-RANGE OF ADDITIVES IN MARINE PLASTICS AND THEIR EXPOSURE TO SEABIRDS

Rei Yamashita<sup>1</sup> (rei@cc.tuat.ac.jp), Hideshige Takada<sup>1</sup> (shige@cc.tuat.ac.jp), Nagako Hiki<sup>1</sup> (nagako0207@gmail.com), Hiroya Sato<sup>1</sup> (hiroyan0122@gmail.com), Kosuke Tanaka<sup>2</sup> (kosuke.t0423@gmail.com), Fumika Kashiwada<sup>1</sup> (s159805y@st.go.tuat.ac.jp), Yutaka Watanuki<sup>3</sup> (ywata@fish.hokudai.ac.jp)

<sup>1</sup> Laboratory of Organic Geochemistry, Faculty of Agriculture, Tokyo University of Agriculture & Technology, 3-5-8, Saiwai-cho, Fuchu, Tokyo, 183-8509, Japan

<sup>2</sup> Laboratory of Toxicology, Department of Environmental Veterinary Science, Faculty of Veterinary Medicine, Hokkaido University, Kita 18, Nishi 9, Kita-ku, Sapporo, Hokkaido, 060-0818, Japan

<sup>3</sup> Laboratory of Marine Ecology, Faculty of Fisheries Science, Hokkaido University, 3-1-1, Minato-cho, Hakodate, Hokkaido, 041-8611, Japan

Additives are essential components of plastic products. Some of them are hazardous to marine organisms and human. They can be also utilized as indicators of plastic-mediated chemical exposure to marine organisms. The present study measured wide range of additives including plasticizers (phthalates), UV absorbers (benzotriazoles and benzophenones), flame retardants (PBDEs, DBDPE, HBCDs, and tetrabromo bisphenol A) in large plastic fragments and microplastic fragments and pellets on sandy beaches, and buoyant microplastics in coastal and open ocean, plastic fragments from northern fulmar from the

Netherlands, and preen gland oil from seabirds globally collected. UV absorbers, especially benzotriazoles, are widely detected in large plastic fragments on the beaches and plastic fragments in seabirds' stomach. They are also detected in preen gland oil from some species of seabirds such as black footed albatross from Tern Island, Hawaii. Brominated flame retardants such as BDE-209 and DBDPE were also detected in the plastic fragments from the stomach of northern fulmar. They are also detected in preen gland oil from several species of seabirds from some locations in the world such as Hawaii, Western Australia, and Marion Island. These suggest transfer of plastic additives from ingested plastics to the tissue of seabirds. Among beached microplastics, plastic fragments contained more BDE-209 than pellets. In buoyant microplastics even from open ocean, BDE-209 was significantly detected. This means that hydrophobic additives, i.e., BDE-209, is retained in microplastics even after fragmentation and suspension in seawater. These hydrophobic additives could be source of chemical exposure to small marine organisms in remote ecosystem.

#### RESULTS OF A GAP ANALYSIS FOR SEABIRD MONITORING IN THE US TROPICAL PACIFIC

Lindsay C. Young<sup>\*</sup> ([lindsay@pacificrimconservation.org](mailto:lindsay@pacificrimconservation.org)) and Eric A. VanderWerf ([eric@pacificrimconservation.org](mailto:eric@pacificrimconservation.org))

<sup>\*</sup> Pacific Rim Conservation, P.O. Box 61827, Honolulu, HI 96839, USA

The U.S. Tropical Pacific (USTP) is a globally important area for seabirds with at least 31 seabird species breeding in five geographic regions: Main Hawaiian Islands (MHI), Northwestern Hawaiian Islands (NWHI), Mariana Islands (MI), American Samoa (AS), and Pacific Remote Islands Marine National Monument (Remotes). A questionnaire was distributed to 30 resource managers and biologists throughout the USTP to conduct a gap analysis on species (and regions) being monitored and monitoring techniques. Responses received characterizing seabird monitoring at 43 sites on 30 islands. Goals of individual monitoring programs varied and all programs had multiple goals; the most common being monitoring population size and trend and measuring effects of threats and/or management. The 31 seabird species in the USTP varied in their distribution, with some species being widespread (e.g., Wedge-tailed Shearwater, Red-tailed Tropicbird, Black Noddy), and

other species being restricted to just one or a few islands in one region (e.g., Short-tailed Albatross, Tahiti Petrel, Tropical Shearwater, White-throated Storm-petrel). Thirty species (97%) were monitored in at least a portion of their range, but significant gaps existed for White-tailed Tropicbird, Gray Noddy, Tahiti Petrel and White-throated Storm-petrel. The proportion of islands where each species was monitored varied considerably- from all islands to just one. Species were monitored on an average of 64% of the islands on which they occurred in all geographic regions combined. Monitoring levels were highest in the MHI (65%), NWHI (63%), and Remotes (91%), and lower in the MI (26%) and AS (33%). Species monitored most were larger ground nesting species, and those listed under the Endangered Species Act. The results serve as a starting point from which to prioritize species and regions for seabird monitoring.

#### MULTI-DECADAL ASSESSMENT OF PENGUIN DIET FROM SPACE – LINKING ANTARCTIC FOOD WEB DYNAMICS TO POPULATION CHANGE

Casey Youngflesh (casey.youngflesh@uconn.edu)<sup>1,2,\*</sup>,  
Christian Che-Castaldo (checastaldo@icloud.com)<sup>1,3</sup>,  
Matthew Schwaller (matt.schwaller@gmail.com)<sup>1</sup>,  
Shawn Serbin (sserbin@bnl.gov)<sup>4</sup>, Michael Polito  
(mpolito@lsu.edu)<sup>5</sup>, Heather J. Lynch  
(heather.lynn@stonybrook.edu)<sup>1</sup>

<sup>1</sup>Stony Brook University, Stony Brook, NY 11790 USA  
<sup>2</sup>Current Address: University of Connecticut, Storrs, CT 06269 USA

<sup>3</sup>Current Address: Mount Saint Helens Institute, Amboy, WA 98601 USA  
<sup>4</sup>Brookhaven National Laboratory, Upton, NY 11973 USA

<sup>5</sup>Louisiana State University, Baton Rouge, LA 70803 USA

\*Presenting author

Rapid climatic change is driving a multitude of ecological shifts around the globe. In Antarctica, changes are apparent in both the distribution and abundance of organisms throughout the food web. However, despite these observations, a holistic understanding of changes in the underlying dynamics of the Antarctic system is lacking. Drawing inference on such processes requires research efforts on large spatial and/or temporal scales, which is often logistically difficult at high latitudes.

In an effort to characterize ecological change in the Antarctic system as reflected in the Adélie penguin (*Pygoscelis adeliae*), a principal marine predator in the Southern Ocean, we develop a novel method that combines remote sensing, field spectroscopy, and stable isotope analysis, to quantify penguin diet over the entirety of the species' global range, from 1984-2013. Using a hierarchical Bayesian approach to account for uncertainty in our analyses, we find that Adélie penguin diet has not changed substantially in recent years but does vary spatially across the continent. We further find that diet is linked to population trends at breeding colonies across the Antarctic.

These results suggest that, despite recent changes in the physical Antarctic environment, food web dynamics, as they pertain to the Adélie penguin, have not shifted substantially over the period analyzed. However, spatial differences in Antarctic food-web dynamics are associated with population processes and may be reflective of past resource exploitation. This work represents a general framework for assessing future ecological change in Antarctic food web dynamics at unprecedented spatial and temporal scales and has important implications for management practices and our understanding of the Antarctic ecosystem.

#### UNMANNED AERIAL VEHICLE USE IN NEST SITE CENSUS OF GREATER CRESTED TERN AND CRITICALLY ENDANGERED CHINESE CRESTED TERN

Chung-Hang, Hung, Kung-Kuo, Chiang<sup>1,2</sup>, Li-Hao, Kuan<sup>3</sup>,  
Le-Ning, Chang<sup>1</sup>, Hsiao-Wei, Yuan  
([hwyuan@ntu.edu.tw](mailto:hwyuan@ntu.edu.tw))<sup>1,\*</sup>

<sup>1</sup>School of Forestry and Resource Conservation, National Taiwan University, Taipei, Taiwan

<sup>2</sup>Wild Bird Society of Taipei, Taipei, Taiwan

<sup>3</sup>Aerial Survey Office, Forestry Bureau, Taipei, Taiwan

The Chinese Crested Tern, *Thalasseus bernsteini* (CCT), is the most critically endangered seabird species in Taiwan. CCT nests sympatrically with the Great Crested Tern, *T. bergii* (GCT), among seven protected islands within the Matsu Island Tern Refuge (MITR). To minimize disturbances during breeding season, we used Unmanned Aerial Vehicles (UAVs) to locate CCT nests and built digital surface models of the protected islands in the MITR. In 2017, we found 10 CCT nests and 1643 GCT nests on Tiejien Island on 8 June, and another 4 CCT nests and 970 GCT nests on 6 July. We

also used generalized linear models to distinguish the effects of elevation, slope, and vegetation coverage on the probability of CCT and GCT nest distribution. The model indicated that GCT prefers to nest on high (>13 m above high tide line), flat (slope < 25°), and less vegetation cover (< 22%) ground, while CCT prefer to nest within higher GCT nest density areas. In addition, we also found that GCT nest density significantly increased with the distance to bird blind, which may imply a negative impact of human disturbance on terns' nest site preference. Overall, we found that the removal of more vegetation on Tiejien Island would provide more nesting areas for CCT and GCT colonies. UAVs also served as an important tool in improving the accuracy and efficiency of seabird colony and habitat monitoring on hard to reach islands.