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BOOK OF ABSTRACTS
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AT-SEA MOVEMENTS AND RANGING BEHAVIORS OF BREEDING WEDGE-TAILED SHEARWATERS (*ARDENNA PACIFICA*) IN THE SUBTROPICAL HAWAIIAN METAPOPULATION

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Within the main Hawaiian Islands (MHI) metapopulation, the largest Wedge-tailed Shearwater (*Ardenna pacifica*) colonies occur on islands and islets of O'ahu, Kaua'i, and two islets west of Kaua'i (Lehua and Ka'ula), with fewer numbers throughout Maui Nui. During 2013–2015, we examined at-sea distributions for chick-rearing shearwaters at 11 colonies throughout the MHI using GPS tags. We identified 614 foraging trips from 299 individuals. (duration: 0.5 to 15 days). Low sample sizes prevented assessing relative importance of long trips; therefore, we examine results from short trips ≤4 days. Behavioral classification revealed birds spent similar proportions of time during daylight in transit, search/forage, and rest behavioral states; transit and search peaked at the beginning and end of the day and was more frequent than rest, which was the dominant behavior at night. Throughout all sites, kernel density core-use included areas adjacent to breeding islands and up to 100–200 km offshore. Within a given island we observed variable but significant core-use-overlap among colonies. In contrast, almost no inter-island overlap occurred among core-use areas for birds from Maui, O'ahu, and Kaua'i sites. Conventional views of interference competition among seabirds have been bolstered by the recent explosion in seabird tracking studies. A recent review found 79% of studies reported inter-colony foraging area segregation (Bolton et al. 2019); however, this review was largely based on seabirds that inhabit boreal and polar latitudes. Therefore, here we consider the degree to which subtropical Wedge-tailed Shearwaters, dependent in part on sub-surface predators, display foraging area segregation.

SYNCHRONOUS COLLAPSE OF FORAGE SPECIES DISRUPTS TROPHIC TRANSFER DURING A PROLONGED MARINE HEATWAVE

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Abstract: Forage fish provide a conduit for energy transfer between plankton and predators in marine ecosystems. In this study, we documented changes in key forage fish populations by examining trends in abundance, and changes in age, growth, and energy content during the North Pacific marine heatwave (PMH) in 2014-2016. We also examined changes in lower and upper trophic levels. We found that indices of capelin, sand lance, and herring abundance or availability declined to historically low levels during the PMH. Changes in age structure, growth, and energy content of capelin, sand lance, and herring were also associated with warming during the heatwave, but not all species responded in the same way. For example, spawning capelin grew faster and matured at a younger age but shorter length than usual, while sand lance in Prince William Sound experienced anomalously low growth rates and lipid storage. These changes in forage fish populations had profound impacts on predator populations in 2015-2016, when seabirds and marine mammals experienced shifts in distribution, unprecedented mass mortality, and reproductive failures in the GOA. In contrast, indices of small and large copepods increased during and after the PMH, which we hypothesize could be related to reduced grazing by planktivores such as forage fish. The persistent PMH coincided with the collapse of multiple forage fish populations and reduced the efficiency of energy transfer through the middle trophic level of pelagic food webs. This disruption in energy flow to higher vertebrate predators caused catastrophic reductions in their numbers and productivity.

SPATIOTEMPORAL VARIATION IN SALMONID PREDATION BY SEABIRDS IN THE HUMBOLDT BAY REGION FROM COLONY RECOVERIES OF PIT TAGS

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Seabirds and waterbirds can impose appreciable mortality on juvenile salmonids in Pacific estuaries, but the degree of mortality risk to outmigrating fish appears to vary substantially over space and time. Describing and explaining this spatiotemporal variation is key to understanding its potential importance in the population dynamics of imperiled fish populations, and their potential importance as prey of seabirds and waterbirds. Marking of salmonids with passive integrated transponder (PIT) tags allows indirect observations of seabird predation via tag recovery. In 2017-19, we searched five Double-crested Cormorant (*Phalacrocorax auritus*) and Caspian Tern (*Hydroprogne caspia*) colonies and two mixed heronries in the vicinities of Humboldt and Trinidad Bays, Humboldt County, California, and located over 6000 PIT tags. 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. We conducted repeat systematic surveys across years to estimate detection probability and tag retention probability, allowing estimation of predation rates on cohorts preceding the first of sampling (even prior to 2010) by assuming similar retention rates in past years. This method demonstrated substantial spatiotemporal variance in predation risk to outmigrating cohorts of imperiled coho salmon stocks, and we discuss potential explanations for this variance including alternative prey availability, runoff events, and variation in abundance and distribution of breeding birds.
Fisheries

RESEARCH AND CONSERVATION NEEDS OF THE EASTERN POPULATION OF DALMATIAN PELICAN (*PELECANUS CRISPUS*)

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Dalmatian Pelican is regarded as Near Threatened by IUCN, however, the eastern population (present known breeding ground in western Mongolia and known wintering site in eastern China) is suffering a serious decline in the past decades and the population is probably as low as about 150 birds. They are still facing threats of illegal hunting and habitat destruction. In July 2019 a Task Force was established for conservation of this population under the East Asian Australasian Flyway Partnership for conservation planning and implementation of this critically endangered population. The most important task at this stage is to understand more on the biology of this species including migration route and important migration staging sites.

SEASONAL AT-SEA DISTRIBUTION OF NORTHERN FULMAR BYCATCH BY BREEDING COLONY

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Pacific Northern Fulmars (*Fulmarus glacialis rodgersii*) taken as bycatch in U.S. North Pacific groundfish fisheries originate largely from four major breeding colonies in Alaska. Using genetic stock identification, we linked 1,500 fulmars from bycatch to their colonies of origin: Pribilof Is., St. Matthew and Hall Is., Chagulak Is. and Semidi Is. We then identified the spatial distribution of these fulmars supplied by the NOAA Pacific Seabird Necropsy program and compared distributions of birds caught during the breeding and non-breeding seasons by colony-of-origin. Broadly, we found that the majority of fulmars sampled were caught along the Bering Sea shelf break, and that this trend was true for all colonies, including for the Semidi Is. colonies in the Gulf of Alaska. We also identified differences between breeding and non-breeding distributions, with a shift from more northerly latitudes along the Bering Sea shelf break in the breeding season, to clusters around the Pribilof Islands and the shelf north of the east Aleutians in the non-breeding season. While these results are biased by the distribution of fishing effort, they provide important insight into the movement and ecology of Alaska Northern Fulmar colonies.

TRANSIENT ELEVATIONS IN CORTICOSTERONE HAVE PERSISTENT IMPACTS ON GENE EXPRESSION IN KITTIWAKE (*RISSA TRIDACTYLA)* CHICKS

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Food shortages elevate glucocorticoids in seabird chicks; early glucocorticoid exposure has the potential to “program” phenotype by inducing long-term changes in behavioral and physiological function. We administered oral corticosterone (CORT) to free-living, food supplemented kittiwake chicks 3x/day from days 10 to 16 post-hatch, to test the hypothesis that early exposure to repeated, transient elevations in CORT have persistent effects on CORT secretion, development and gene expression. We assessed acute effects of treatment by measuring plasma CORT at 15 and 60 min after administration and deposition of feather CORT (fCORT) in concurrently-grown portions of primaries. We assessed longer-term effects, 9 days after treatments ended, by measuring plasma CORT and using RNASeq to assess gene expression in a non-lethal biopsy of pectoralis muscle. Oral CORT elevated plasma CORT at 15 min but not at 60 min after administration, and increased fCORT in primaries. Treatment did not change growth, begging behavior, or baseline CORT production. Though we predicted changes in expression of metabolic genes, the most consistent effect of oral CORT on gene expression was a significant, widespread downregulation of immune genes in CORT chicks compared to unhandled controls. Thus despite the apparent ability to tolerate repeated acute elevations in glucocorticoids, young kittiwakes may bear

potentially costly, "invisible" consequences that persist well beyond exposure. Alteration of immune function has long been recognized as a mechanism linking early glucocorticoid exposure with fitness costs that manifest later in life, and here we identify some of the genes that may underlie this programming.

CONSISTENT POST-BREEDING MOVEMENTS OF MARBLED MURRELETS FROM BRITISH COLUMBIA TO ALASKA (2014-2016).

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Knowledge of patterns of seasonal movements are required to inform examinations of the distribution and abundance of marine birds to support of conservation efforts. We deployed solar satellite transmitters to track the movements of Marbled Murrelet (*Brachyramphus marmoratus*) during the breeding and post breeding periods. We tagged birds in British Columbia, Canada, over three years (2014-2016, n=27), from three different Marbled Murrelet conservation regions. The tags were most useful in revealing long distance movements of birds following reproductive attempts. In all three years birds from B.C. moved to Alaska in the post breeding period. In 2014, a murrelet from the Northern Mainland Coast conservation region (Kitimat) travelled to waters near Kodiak Island in August. In July 2015, a bird from the Southern Mainland Coast conservation region (Desolation Sound) travelled to Glacier Bay. In early August 2016, a bird from the West and North Vancouver Island conservation region (Clayoquot Sound) moved to the Alexander Archipelago in the Alaskan panhandle. Historical and ongoing time series counts of murrelets in Alaska show a swelling of numbers in July and August, consistent with the timing of arrival of BC birds, and indicate that our results likely reflect annual movement patterns. The arrival of BC birds in Alaska also coincides with the timing of salmon gill net fisheries, which presents a mortality risk to murrelets in areas of known overlap, such as Kodiak Island. Our tracking work demonstrates strong connectivity between Alaskan and Canadian populations.

SQUEEZED BY A HABITAT SPLIT: WARM OCEAN CONDITIONS AND OLD-FOREST LOSS INTERACT TO REDUCE LONG-TERM OCCUPANCY OF THE THREATENED MARBLED MURRELET

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Theory predicts that species that require multiple habitat types simultaneously should be more sensitive to anthropogenic pressures, yet tests of this prediction are rare. We evaluated the hypothesis that occupancy of the threatened Marbled Murrelet (*Brachyramphus marmoratus*) was driven by the synergistic effects of nesting habitat loss and changing ocean conditions. We paired 70,700 murrelet occupancy surveys at 19,837 sites across 23 years from the Oregon Coast Range with annual data on the extent of older forest and quantitative estimates of biophysical ocean conditions. Dynamic occupancy models indicated that murrelet nesting in any given year ("settlement") was strongly reduced during warm ocean conditions with apparent low prey availability. Landscapes containing greater and more contiguous older forest and those closer to the ocean showed reduced rates of temporary absence ("vacancy"). These results suggest that prospective timber harvest locations should be surveyed only in years following good ocean years, or for periods that exceed the maximum length of strings of poor ocean conditions (i.e. >2 successive years). In addition, continued conservation of contiguous older forest closer to the ocean (at least within 48 km) will likely provide the greatest benefit toward recovering murrelet populations. Given predictions of accelerated ocean warming and increased global timber demand, our results suggest murrelet populations will continue to be impacted by deterioration of the two habitats upon which they depend.

CHANGES IN POPULATION SIZE AND SPATIAL DISTRIBUTION OF COMMON MURRES IN OREGON, 1988 - 2014

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The common murre (*Uria aalge*) is the most abundant species of seabird breeding along the coast of Oregon, where aerial photographs have been taken of each colony in the state annually since 1988 by the US Fish & Wildlife Service. We estimated the statewide population from these photographs for four separate years during a 26-year period from 1988 to 2014 in order to derive trends in the population size and spatial distribution of the species. The estimated breeding population of murres in Oregon declined by ~160,000 individuals (23%) between 1988 and 2014, from ~690,000 to ~530,000 murres. We also found a southern shift in the distribution of the murre breeding population during this period. In 1988, > 50% of the Oregon murre population was breeding at the northern one-third of colony sites but that proportion decreased to < 20% by 2014, a decline of ~260,000 murres. During the same period, the central and southern colonies along the Oregon coast gained ~100,000 murres. Multiple factors may be driving this population decline and the distributional shift including disturbance from bald eagles (*Haliaeetus leucocephalus*), changing ocean conditions, and emigration from the state. Our results will inform marine spatial planning efforts including renewable energy development projects in Oregon's nearshore waters and contribute to the development of site-specific protocols under the US Fish & Wildlife Service National Protocol Framework for Monitoring Common Murre and Brandt's Cormorant Breeding Colonies in the California Current System.

WINTER HABITAT ASSOCIATIONS OF MARINE PREDATORS IN THE NORTHERN CALIFORNIA CURRENT USING CLASSIFICATION AND REGRESSION TREE

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Given a predator's imperfect knowledge of prey distribution, predators often use environmental or biological cues as proxies to increase the probability of encountering prey patches, especially under low productivity conditions. Predator-habitat associations can be used for many applications, such as targeted surveys, distribution models, and marine spatial planning. However, little is known about habitat associations for seabirds and marine mammals during low productivity winter periods in temperate latitudes due to few winter at-sea surveys. In this study, we aimed to quantify marine predator assemblages and their habitat associations during the winter downwelling season (i.e. low productivity) of the northern California Current. Marine bird and mammal counts were collected during at-sea surveys across four years (Feb-Mar 2006, 2008, 2009, 2012). We used the count data of seabird species that comprised >1% of total abundance and all marine mammal species. Taxonomic groups, such as piscivorous and planktivorous alcids, were put into a principal component analysis, which indicated further clustering of some groups based on seven habitat characteristics (e.g., distance from shore, depth, SST). As survey data often do not meet the assumptions of parametric statistics and transformations can reduce precision, we used a non-parametric multivariate analysis (Classification and Regression Tree, CART), to analyze habitat associations within groups. The CART split groups based on a

few important habitat variables (e.g., depth, SST). These findings address a key knowledge gap in the northern California Current by elucidating habitat features that support energy flow to upper trophic levels during winter downwelling.

CLIMATE CHANGE AND ITS IMPACTS ON NORTH PACIFIC MARINE ECOSYSTEMS

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Global warming has important implications for the North Pacific's marine ecosystems. Systematic changes already appear to be happening in the Bering Sea due to a decline in Arctic sea ice. In the eastern portion of the basin, a marine heat wave (MHW) that occurred in 2014-16 was especially extreme in its magnitude because of background warming. Long-term trends are also emerging above the natural variability elsewhere. These types of changes are expected to become increasingly evident with time. The responses that have been observed to current warming trends, and recent MHWs, provide insights on probable future changes in the marine ecosystems of the North Pacific. Advances in the modeling of the abundances and distributions of marine populations also show promise, with caveats. Continued progress in our understanding of the effects of climate on the marine ecosystems of the North Pacific is crucial to effective management of these resources.

LINKING TROPHIC LEVELS: BRANDT'S CORMORANTS AND FORAGE FISH IN THE CENTRAL CALIFORNIA CURRENT

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The occurrence and causes of abrupt ecosystem shifts is a major conservation concern with increasing climate variability. In the California Current System and beyond, seabird demography has been linked to physical and biological variability in the environment. However understanding mechanisms, such as trophic linkages, is important to characterize thresholds or predict when relationships may break down. Brandt's cormorants (*Phalacrocorax penicillatus*) on Alcatraz Island in the San Francisco Bay comprise one of only two estuarine colonies of this species. While long-term productivity is consistently higher than at other locations within the region, temporary breeding abandonment occurred on Alcatraz in 2009. Cormorants subsequently returned but productivity has been more variable. Using time-series on cormorant reproductive success and diet from regurgitated pellets, we investigate links with forage fish populations. The diet of Brandt's cormorants on Alcatraz is diverse, shifts seasonally and is marginally related to the fish community (including groundfishes and northern anchovy *Engraulis mordax*) sampled at spatially relevant stations within the San Francisco Bay. However, despite complexities, inter-annual variability in diet and reproductive success are primarily related to coastal anchovy abundance. Multiple main prey species, temporal diet variability and the estuary-ocean interface at this colony make unraveling trophic connections challenging, however, we aim to better understand cormorant responses to fluctuating prey communities and resilience strategies in an increasingly variable environment.

FORAGING DISTRIBUTION OF BREEDING CALIFORNIA GULLS (*LARUS CALIFORNICUS*) IN THE SOUTH SAN FRANCISCO BAY

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California gulls (*Larus californicus*) play a major role in their ecosystems. They act as nest predators to other bird species and can shape their habitats by introducing nutrients from outside sources. Due to their high motility gulls heavily impact even remote coastal and offshore ecosystems. California gulls have been documented feeding opportunistically at landfills in the San Francisco Bay and can spread food, bacteria, and waste from these landfills into neighboring areas. Protected wildlife habitat in the San Francisco Bay is located in close proximity to urban landfills, making these habitats particularly susceptible to the spread of waste material from these surrounding landfills. California gulls are of particular interest because their breeding population has increased exponentially since their arrival to the San Francisco Bay in the early 1980's. We used GPS loggers to track the foraging distribution of California gulls during the breeding season in May 2019. We captured and tagged gulls from two colonies on the Don Edwards San Francisco Bay National Wildlife Refuge (the refuge). Preliminary data show that California gulls are primarily utilizing terrestrial habitats to forage during the breeding season. Individual gulls appear to visit the same locations. There was insufficient data to determine any trends between colonies. We hope to capture and tag more California gulls during the 2020 breeding season in order to draw more conclusive results.

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

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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 2018 and 2019 at three sites with ongoing annual seabird monitoring camps as well as at less frequently monitored sites. We also discuss further refinements for improvements based on current results.

USE OF VIDEO CAMERAS TO QUANTIFY CHICK PROVISIONING RATES IN THE MARBLED MURRELET (*BRACHYRAMPHUS MARMORATUS*)

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Understanding factors that limit reproductive success is essential for recovering listed species. For the Marbled Murrelet, these factors are not adequately understood due, in large part, to the substantial challenges involved with locating and monitoring active nests. Studies that provide information on nesting behavior, including chick provisioning rates, are needed to understand potential constraints on offspring production. During summers 2018–2019, we located 12 active murrelet nests in the central Oregon Coast Range and used customized digital video cameras to provide around-the-clock surveillance of nests. We obtained comprehensive footage at 6 nests during the chick-rearing period and documented >300 chick-feeding events in >8200 hours of footage. Of these 6 nests, 4 were successful, 1 was depredated, and 1 failed due to suspected chick starvation; age at fledging ranged from 33 days to 45 days. Observed number of feedings per day varied between 0 and 6, and the longest gap between feedings was 47 hours. When possible, prey items were identified to the lowest taxon level. Pacific Sandlance (*Ammodytes hexapterus*) and Surf Smelt (*Hypomesus pretiosus*) were frequently recorded and may represent a significant portion of chick diet. We quantified how provisioning rates varied between sexes and changed throughout the period of chick development. Overall, this study improves our understanding of how chick provisioning rates vary between nests and how it is linked to reproductive success of the threatened Marbled Murrelet.

HEERMANN´S GULL (LARUS HEERMANNI) BREEDING STRATEGIES IN A CHANGING WORLD: ARE THEY ADAPTIVE ANY LONGER?

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In long-lived species, such as seabirds, reproductive effort and success at age class, and longevity, play a crucial role in their life history. Isla Rasa, located in the Gulf of California, is the nesting site of 95% of the world's Hermann's Gull (Larus heermanni) population. This species has demonstrated reproductive strategies such as avoiding reproduction until favorable food conditions exist, longevity, late sexual maturation and low reproductive rate. However, individual differences have not yet been characterized. Our objective was to assess the effect of the age, longevity and environmental conditions (normal and anomalous sea surface temperature years) on the total chicks produced per female. We analyzed females from seven cohorts, banded between 1984 and 1993, and recaptured in subsequent years until 2013. We divided females who laid eggs and hatched chicks both in normal and anomalous years (bold females), from females who did not lay eggs or, if they did, did not hatch chicks in anomalous years

(conservative females). Our results show that bold females form a small percentage of the whole population, live significantly shorter lives and lay a significantly smaller number of eggs than conservative females. However, there was no difference in the total number of chicks fledged between bold and conservative females. This suggests that both strategies do not have a clear adaptive advantage and have been preserved in the population. If anomalous years become more frequent in the future, bold females may be at a selective advantage over the conservative ones.

C02 RISING: THE DEPENDENCE ON FOSSIL FUELS THAT DROVE SEABIRD RESEARCH NOW THREATENS ALL SEABIRDS

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Much seabird research during the last half century has been conducted to facilitate fossil fuel extraction. An interest in West Coast seabirds began in 1971 when USFWS, in one of the first Environmental Impact Statements, assessed seabird populations at risk from the shipment of oil from the Trans-Alaska Pipeline. Research then expanded greatly with a nationwide Outer Continental Shelf Assessment Program to decrease dependence on foreign oil. Areas thought to support profitable lease sales received large-scale colony censusing, pelagic surveys and colony studies while seabirds in other areas were ignored. The promise of lease sales, combined with the fear or reality of spilled oil, provided agencies with leverage in obtaining funds. With limited existing agency staffing, contracts and grants were provided to academia, greatly increasing the number of graduate students studying seabirds. While intellectual curiosity, academic advancement, or even a love of seabirds might have fueled many of the researchers, funding for their work was available because the country needed cheap fossil fuel to maintain a growth economy.
Overlooked by wildlife and resource agencies, and unknown then to seabird researchers, was how fossil fuel dependence would affect the global environment. Industry has apparently been cognizant of the disastrous effects for some time but the general public has only recently become aware of the issues. While we now know ocean warming and acidification from increasing CO2 levels may result in extinction of many seabirds, government is doing little to reduce emissions or our dependence on fossil fuels.

USING HIGH RESOLUTION SATELLITE IMAGERY TO COUNT NESTING PACIFIC ALBATROSS.

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The conservation status of all species is highly dependent on abundance data which, are often limited in geographic or temporal scope. Very high-resolution satellite imagery provides a means to address these limitations and provide remotely-sensed counts of large, colonial species. We used WorldView-2 and

WorldView-3 satellite imagery paired with field counts of three species of nesting albatrosses (*Phoebastria immutabilis*, *P. nigripes*, *P. albatrus*) at two sites (Torishima, Japan and Sand Island, Midway Atoll, Hawaii) to test the ability of satellite image-based counts to predict in-field counts after accounting for multiple image and habitat covariates. Pan-fused images underestimate ground count by about 31%, after including vegetation cover and sun elevation in the model. Panchromatic images more accurately model in-field count when taking into account platform, species and vegetation cover with errors of -40-25%. We applied the best-performing, panchromatic model to estimate an inaccessible colony of *P. albatrus* breeding in the Senkaku Islands and show the colony has expanded to a minimum of 166 adult birds. With sufficient calibration, we demonstrate that robust, multi-species models can be developed to expand the use of very high-resolution satellite imagery to satisfy monitoring objectives constrained by time, funds, or accessibility.

CONTRASTS IN ATTENDANCE, BREEDING PHENOLOGY, CONSUMPTION PATTERNS, STRESS, AND TRAIT EXPRESSION MARK CLIMATE SHIFT AT BERING STRAIT

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Auklet colonies at Bering Strait are strategically positioned for studying global change. We evaluated this during 2015-2016 while a major environmental shift was underway. We noted contrasts in behavior and physiology of auklets at Little Diomede I., AK. Colony attendance of crested auklets (*Aethia cristatella*) was down by 35-50% in latter June 2016 compared to the same date in 2015. Although crested auklets are specialist foragers, their C/N stable isotope values spanned three times the range in 2016 compared to 2015. Red blood cells in 2015 had greater enrichment of $\delta^{13}C$ ($t_{0.05(2)86} = 11.3$, $p < 0.001$) and lower values of $\delta^{15}N$ ($t_{0.05(2)78} = 11.4$, $p < 0.001$). An unusual marine distribution was noted in latter June 2016, with large aggregations of crested auklets foraging adjacent the beach at the Seward Peninsula. Baseline corticosterone was higher in 2016 ($t_{0.05(2)27} = 2.56$, $p < 0.05$), suggesting elevated physiological stress. Fewer endogenous resources could explain why there was weaker expression of secondary sexual traits in 2016. Expression of the crested auklet's citrus-like odorant was less evident and ceased earlier, while acquisition of bill pigment was incomplete in 11% of crested auklets captured (n=82). Least auklets also had reduced colony attendance in latter June and manifested an apparent shift in consumption patterns. Growing primary feathers of least auklets, had lower $\delta^{13}C$ values ($t_{0.05(2)21} = -4.06$, $p< 0.001$) and higher $\delta^{15}N$ ($t_{0.05(2)21} = 8.22$, $p< 0.001$) in 2016. We conclude that additive effects of increased ocean heat disrupted pelagic food webs in Bering Strait, and negatively impacted fitness of planktivores, leading to a worsening trend from 2015 to 2016.

NOVEL FLUOROCHROME INCREASES SOCIAL ATTRACTION AND DISCRIMINATES PHENOTYPE AND STATUS IN CRESTED AUKLETS (AETHIA CRISTATELLA)

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According to sensory sexual exploitation, colorful ornaments can arise from exploitation of a sensory bias in the receiver. We tested if this could be true for the yellow-orange bill pigment of the crested auklet (*Aethia cristatella*). We used three spectroscopy techniques to study properties of the pigment. We manipulated the bill fluorescence of identical crested auklet decoys in paired trials to test the hypothesis that fluorescence could increase social attraction. With Raman spectroscopy we established that the pigment is not a carotenoid. We also identified a fluorescence peak at ~527 nm, that is similar to a yellow fluorescent protein. With fluorescence spectroscopy (FS) showed that the crested auklet fluorochrome is unique in the Genus Aethia. We also found two phenotypes (single-band and two-band fluorescence). All samples from St. Lawrence I. were single-band (n=11), but we found both phenotypes at Little Diomede I. (n=10). Individuals differed quantitatively in intensity of fluorescence, but mean values did not differ between colonies. With absorbance spectroscopy we showed the pigment is similar but distinct from known pterin compounds. We also showed that its absorbance spectrum overlaps with the extracted pigment of euphausiids, a favored food of crested auklets. Crested auklets preferred fluorescent bills, which they approached at a higher frequency ($t_{(130)} = 3.14$, $p_{1\text{-tailed}} = 0.001$), and touched at a higher frequency ($t_{(42)} = 1.77$, $p_{1\text{-tailed}} = 0.04$), most notably a behavior termed “billing”. We conclude that the crested auklet’s novel bill fluorescence could have evolved by sensory sexual exploitation, by exploiting a preexisting bias in crested auklet visual systems for this bright color.

THE NORTH PACIFIC PELAGIC SEABIRD DATABASE – VERSION 3.0 UPDATE

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The North Pacific Pelagic Seabird Database (NPPSD) was created in 2005 by the U.S. Geological Survey (USGS) and U.S. Fish and Wildlife Service (FWS), with additional support from the North Pacific Marine Research Institute to consolidate available data (~61,000 transects conducted during 1975-2002) on the oceanic distribution of seabirds in the North Pacific, primarily Alaska. The NPPSD was expanded greatly in Version 2.0 to include ~290,000 more transects (1973-2012) conducted in adjacent waters of Russia, Japan, Alaska, Canada and the US West Coast. With additional funding from the Bureau of Ocean and Energy Management (BOEM) and collaboration with colleagues in FWS, Gulf Watch Alaska (EVOSTC funded) and the National Park Service, we have recently expanded the NPPSD by 28% with the addition of another ~100,000 transects (2013-2019). These include extensive surveys conducted in the Bering and Chukchi seas (FWS, funded by BOEM and NPRB), Prince William Sound (PWS Science Center, USGS, FWS funded by EVOSTC), Gulf of Alaska (FWS, USGS, Kodiak NWR) as well as off the coasts of California and Oregon (Farallon Institute, NMFS) and British Columbia (Environment Canada). Working with BOEM, we are creating a derived NPPSD database that will be informed by the observed distribution and abundance of birds as well as by ancillary predictive environmental data (such as bathymetry, distance from land and shelf-edge, chlorophyll-a, etc.). These “best-fit” estimates of seabird distribution can then be used to answer the usual questions (above, e.g.) more accurately, as well as provide a useful database for estimating the size of vulnerable seabird species and populations in developed/developing marine areas of Alaska.

WINTER DISTRIBUTIONS AND ACTIVITY BUDGETS OF RED-LEGGED KITTIWAKES FROM TWO DISTANT BREEDING COLONIES IN THE BERING SEA

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The red-legged kittiwake (*Rissa brevirostris*) breeds at only a few colonies in the Bering Sea and may be particularly sensitive to changes in the pelagic marine environment due to a small population size, limited range, and specialized diet. Over the last decades, populations at St. George Island in the southeastern Bering Sea and Buldir Island in the western Aleutians have generally increased or remained fairly constant. However, recently both colonies have experienced some years of poor breeding success or complete breeding failure, and the 2017 population count at St. George Island was markedly low. Knowing where birds winter may help to understand drivers of breeding success and population change at these colonies. We compared winter movements of red-legged kittiwakes from these two colonies from 2016-2018 using geolocators. Birds from Buldir headed west immediately after the breeding season in September to spend the fall and winter months in the Sea of Okhostk and off the Kuril Islands. In contrast, birds from St. George spent the fall in the northern Bering Sea before overlapping with the Buldir birds in the western subarctic gyre from December through February. Birds from both colonies began moving east towards their breeding colonies by March and were at their colony sites by April. Activity budgets during the non-breeding season were comparable between the two colonies. Our results highlight similar large-scale habitat use in the winter months, with colony separation in the fall and spring. These distribution differences may have implications for demographic trends at these two colonies.

THE COMPLEXITIES OF SEABIRD DEMOGRAPHICS IN A CHANGING ENVIRONMENT – ADÉLIE PENGUINS IN THE SOUTHERN ROSS SEA, ANTARCTICA

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The impacts of environmental variation on key demographic rates are well-documented for many seabirds across a range of ecosystems. However, direct links with population trajectories can be much harder to establish given the complexities of seabird life history strategies. These demographic complexities can make it challenging to disentangle patterns of population change associated with

environmental changes, particularly in ecosystems and locations where environmental change may not yet be evident. In addition, the mechanisms that drive population size patterns are as important to understand as the patterns themselves, particularly when conservation is the goal. As an example, Adélie penguins (*Pygoscelis adeliae*) generally exhibit high survival, strong breeding philopatry and delayed maturation, but environmental variation can also lead to periods of variable survival and relaxed breeding philopatry. In contrast, the dynamics of juvenile survival, age-at-1st reproduction, and breeding propensity are poorly understood for this species, but likely also play a large role in population dynamics. Using a long-term mark-resight data set (18 years) collected on birds banded as chicks at 3 colonies, and multi-state capture-recapture models, I explored temporal variation on subadult survival, age-related recruitment and breeding propensity. Age-related effects can mimic or mask environmental relationships, particularly when confounded with time. Thus, a long time series that encompasses the average life-span of individuals, and models that can disentangle age from time effects, are important for understanding the effects of environmental change on vital rates and population trajectories in species with complex life histories.

MODELING CHANGES IN SEABIRD DISTRIBUTION AND ABUNDANCE FOLLOWING RAT ERADICATION AT TETIAROA ATOLL, FRENCH POLYNESIA

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Removal of non-native mammals from breeding colonies is often a critical first step in seabird conservation and restoration. The impact of eradication efforts on seabird populations is often uncertain but can be informed by baseline data on habitat characteristics and seabird abundance prior to eradication. Non-native Polynesian (*Rattus exulans*) and Black (*R. rattus*) Rats are slated for eradication at Tetiaroa, a small (3,366 ha) coral atoll within French Polynesia, in September 2020. Ten seabird species, including the Red-footed Booby (*S. sula*), Brown Noddy (*Anous stolidus*), and Sooty Tern (*Onychoprion fuscatus*), breed here across twelve low-lying coral islets (i.e., “motus”). In November 2019, we sampled 40 locations across 11 motus to quantify habitat and establish baseline information on seabird and rat presence. At each location, we deployed one acoustic recording device to monitor seabird activity and two baits to determine rat presence for one week. We also conducted a rapid habitat assessment at each site and initiated a banding program to provide information on seabird abundance, survival, and site fidelity. We will present pre-treatment results of acoustic monitoring, rat monitoring, and habitat assessment. Preliminary results indicate rats are present on most motus and seabird activity is restricted to rat-free motus or small portions of rat-occupied motus. These baseline

data are the first step to understanding how seabirds will respond to rat eradication on Tetiaroa. Results will inform the development of a model to predict changes in seabird abundance and distribution following eradication on a tropical atoll and can be used to inform conservation actions to prioritize islands for rat eradication.

ESTIMATING FORAGING SUCCESS OF THICK-BILLED MURRES (URIA LOMVIA) IN RESPONSE TO SEA ICE EXTENT IN THE CANADIAN ARCTIC

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The Arctic is presently experiencing greater inter-annual variability in sea ice dynamics, coinciding with an overall decline in sea ice extent. As trophic dynamics in marine Arctic systems are influenced by sea ice dynamics, rapidly changing sea ice conditions can affect the distribution and abundance of fish and invertebrates. Thick-billed murres (*Uria lomvia*), a cliff-nesting seabird species which prey upon invertebrates, benthic fish, and pelagic fish, could thus be negatively affected by changing sea ice dynamics. However, if murres exhibit the ability to alter their foraging strategies in response to changes in environmental conditions, it could buffer individuals (or even populations) from the adverse effects associated with changing ecosystem dynamics. To determine how variation in sea ice will impact the foraging decisions made by murres, we deployed GPS accelerometers during the incubation and chick-rearing stages at Coats Island, Nunavut, Canada in 2018/2019, and measured weekly sea ice extent throughout the breeding period. To determine the success of foraging trips, we blood sampled murres before/after GPS deployments to quantify energetic hormones (corticosterone) and energetic metabolites (non-esterified fatty acids, beta-hydroxybutyrate, and triglycerides). By combining spatial foraging data with energetic physiology in years of varying ice conditions, we can determine whether the degree of foraging flexibility proximately affects the energetic budgets that ultimately impact breeding success. Overall, this type of integrative approach will allow researchers to predict which individuals and populations will be able to withstand major climatic changes.

ON THE IMPORTANCE OF RECORDING FIELD NOTES

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As Field Biologists we are fortunate to be able to visit many remote, unique, and biologically important locations around the planet. Many such locations are seldom visited, and frequently there is scant information available regarding the overall biological setting of our field sites. When information is

available, it is often the product of diligent previous biologists who have recorded a variety of details spanning multiple disciplines – not just a narrow focus on the specific subject of a study. For generations biologists have recorded their observations in field notes, or more properly, in a field journal. We are fortunate to have access to the daily records of such luminaries as Charles Darwin, Alfred Russell Wallace, Elliot Coues and many others. These valuable records paint a unique picture of a specific location at a specific moment in time. We owe it to future generations to record as much biological information about our field sites as possible. There are many approaches to keeping field notes / a journal. Eminent biologist Joseph Grinnell established a comprehensive method for recording important information. Such records are valuable for a variety of purposes, not the least of which is the recording of seemingly unimportant information that may be of critical importance in the near or distant future. This paper presents techniques and a variety of reasons for keeping detailed records.

AT-SEA DISTRIBUTION PATTERNS AND POPULATION SIZE OF THE ASHY STORM-PETREL *OCEANODROMA HOMOCHROA*

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Neither the at-sea range nor the breeding grounds of cavity-nesting seabirds have been so thoroughly investigated as for Ashy Storm-Petrel (ASSP), an IUCN “threatened species.” We analyzed aerial and ship tracks, 1980-2017 (~497 000 km or 89 642 km^2; 7217 ASSPs seen), to estimate the ASSP total population and it’s at-sea distribution. Zero inflated negative binomial model results indicate an estimated total population of about 13 445 ASSPs, with 62% (~8336 birds) in the northern portion of the range, i.e. north of Pt. Conception (especially Monterey Bay north through the Gulf of the Farallones), compared with 38% (~5109; especially waters around northern Channel Islands) in the south; colony numbers from the literature are 68% and 63% of at-sea numbers, respectively. An analysis of data from >1000 well-organized bird-watching surveys during the study period, indicates that at times almost all the population, or a large portion of it, can occur in a single flock near northern submarine canyons during the autumn Oceanic Period, and that such large “molting flocks” have been shifting north since about 2007. Reasons for the northward shift remain a mystery but could include disturbance from growing numbers of baleen whales, added to boat traffic. The apparent mismatch in population size between at-sea numbers and colony-based numbers likely involves the especially difficult-to-estimate non-breeding portion, including members of a “floating” portion, i.e. adults capable of breeding but denied access to limited availability of breeding sites by intraspecific competition.

HARNESSING THE POWER OF NEXT-GENERATION SEQUENCING TO CHARACTERIZE THE DIET OF MARBLED MURRELETS

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Marbled murrelets (*Brachyramphus marmoratus*) are threatened throughout their range due to loss of their old-growth nesting habitat, low recruitments, and changes in marine environment, including prey. While some nesting habitat management and predator managements programs have been implemented, it is increasingly recognized that changes in marine foraging conditions are also among the most important mechanisms that are thought to be responsible for sustained low murrelet recruitment. However, dietary information for murrelets is scarce because of the species' secretive inland nesting habits and challenges of monitoring prey capture at sea. Recent advances in DNA sequencing offer a promising tool for characterizing diet by sequencing massive amounts of prey DNA fragments collected from predator fecal material. In this study, we used next-generation sequencing technology to characterize species-level diet of marbled murrelets in the coastal waters of California and Oregon from DNA extracted from fecal material collected from birds captured at sea in 2016 and 2017. We optimized primers that amplified DNA from fish, cephalopod, shrimp/krill, and other decapods. Murrelets in Oregon consumed a wider variety of prey items compared to California. Pacific herring (*Clupea pallasii*) and California anchovy (*Engraulis mordax*) were the most commonly sequenced prey items for Oregon and California, respectively. Our research will help identify key forage species for murrelets; more broadly, an improved understanding of marbled murrelet diet could provide key information to prevent the further decline of this species.

SUCCESSFUL TREE-NESTING DOUBLE-CRESTED CORMORANTS: EARLIER NESTING BIRDS MORE LIKELY TO HAVE POST-FLEDGING PARENTAL CARE

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Post-fledging parental care in seabirds is predicted to be partially constrained by season duration in temperate latitudes. In this study, I tested whether Double-crested Cormorants (*Phalacrocorax auritus*) that nested earlier, and successfully fledged chicks, were more likely to have post-fledging parental care compared to those that initiated nesting later at a colony in Ontario, Canada. For ten nesting seasons (2010-2019), I annually tracked the fate of a sample of tree-nesting cormorants (range 62-170 nests). Nests were visually checked each week and their status recorded. For nests that successfully fledged chicks (42 days or older), post-fledging parental care was inferred by the presence of adult(s) at a nest after chicks had fledged but was also supported by focal observations. On average, 50.3% ± 0.98 SD of successful nests had post-fledging parental care. An analysis of 607 successful nests showed a significant difference in nest initiation date (average ± SD Julian date) between nests with (n=304; 111.3 ± 10.4) and without (n=303; 123.0 ± 16.8) post fledging parental care ($p < 0.0005$). Nests with post-fledging parental care also had small, but significant, increase in the number of fledglings (2.2 ± 0.67) compared to nests without (2.0 ± 0.65) ($p < 0.0005$). Focal observations on nests confirmed post-

fledging care: fledglings visiting a nest were fed if a parent was present. These findings support the hypothesis that post-fledging parental care is constrained by season duration, but variation in the occurrence of the behavior may be driven by number of fledglings.

REPRODUCTIVE SUCCESS AT WEDGE-TAILED SHEARWATER (ARDENNA PACIFICA) COLONIES IN MAUI NUI

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The Wedge-Tailed Shearwater (Ardenna pacifica) is indigenous to Hawai'i and one of the most abundant seabird species in the Hawaiian Islands. In Maui Nui, mark and recapture data for this species dates back to 2002. From this dataset, we have learned that although there is equivalent survivorship for established adults among four colonies (Hawea, Mo'omomi, Kāma'ole III and Ho'okipa), only two of the colonies - Hawea and Mo'omomi - are growing in size. Kāma'ole III and Ho'okipa remain stagnant. We hypothesize this pattern is a result of differential reproductive success. Thus, we monitored the egg production and chick fledge rate at all four colonies in 2019. We also considered the differing degrees of protective management at each colony. At the beginning of the breeding season, a scattered selection of 50 active burrows were marked at each colony. The burrows were monitored for activity up to three times during the reproductive season. The results indicate that the growing colonies have higher reproductive success (Hawea=80%, Mo'omomi=64%, Kāma'ole III=54%, and Ho'okipa=30%). Of particular note is the result from the Kāma'ole III colony. Historically, the colony yielded very few chicks during the October mark and recapture event. However, since habitat restoration began in 2019 and predator control was reinstated in 2018, more chicks have been located at this colony. Our findings suggest that both predator control and habitat restoration are necessary for optimal reproductive success at Wedge-Tailed Shearwater colonies. More broadly, protective management can have rapid and positive effects on seabird colonies.

RE-ENVISIONING THE APPROACH TO PREDATOR CONTROL IN A UNIQUE SEABIRD HABITAT

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On leeward Haleakalā, Maui Nui Seabird Recovery Project's efforts to monitor and protect endangered ʻUaʻu (*Pterodroma sandwichensis,* Hawaiian petrel*)* have been successful, as the number of active burrows and reproductive success rates have increased since monitoring began in 2014. Although predator abundance is locally low, feral cats (*Felis catus*) and small Indian mongoose (*Herpestes auropunctatus*) freely traverse the landscape and target ʻUaʻu burrows. We suggest that the current approach of intensive predator control near nesting sites is marginally effective due to behavioral patterns and large home ranges of the predators.

Predator activity is assessed through standardized surveys, and by monitoring game camera data from ‘Ua‘u burrows. Traps are maintained near areas of high burrow density, and are deployed in response to predator activity on cameras. Despite trapping efforts, predators persist, and predation rates (depredated/breeding burrows; annual mean 20%) remain largely unchanged. We show that adopting new trapping technology and methodology can achieve improvements in capture rates; however, we expect the current, reactive strategy to remain limited to local and near-term predation suppression. Additionally, budget and personnel constraints will not be scalable as the colony continues to expand. A change toward a more landscape-level approach that addresses the behavioral ecology of the target species is needed to produce long-term and widespread effects.

SPATIO-TEMPORAL VARIATION IN MARINE SPACE USE OF THE ENDANGERED MARBLED MURRELET (*BRACHYRAMPHUS MARMORATUS*) IN OREGON.

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Identifying movement patterns and habitat use of species is essential for effective conservation. The Marbled Murrelet (*Brachyramphus marmoratus*) is an elusive seabird whose populations have undergone a long-term decline in the Pacific Northwest, and is currently listed as Threatened under the federal Endangered Species Act. The species forages in nearshore waters and nests in mature forest habitat, yet data regarding space use and movements within the marine environment are limited. We captured and VHF radio-tagged 190 adults during the 2017-2019 breeding seasons (May-August) along the central Oregon coast. Birds were monitored for an average of 56 ± 31 days (range: 1-124) via ground- and aerial-based telemetry surveys in which individuals were regularly relocated along a 140 km stretch of coast. Overall, we collected >4800 marine locations, with a mean of 23 ± 19 locations (range: 1-94) collected per bird throughout the breeding season. We found large differences in movements among years: in 2017, tagged birds moved longer-distances and went as far as Washington and California; in contrast, many birds clustered more around specific marine areas in 2018 & 2019, from Pacific City to Florence with overall shorter-distance movements. Birds were mainly located near shore (mean: 1.2 ± 1.3 km), but some occasionally ventured up to 12 km off shore. On average, home range

sizes varied from 51.7 ± 44.7 km² (50% UD), and 241.4 ± 190.3 km² (95% UD) and were smaller compared to similar studies of space use conducted in Washington and California. Altogether, our results help inform future planning and management of marine habitats for the conservation of Marbled Murrelets.

BALD EAGLES AND SEABIRDS: NEW EVIDENCE REVEALS PREDATION EVENTS ON MARBLED MURRELETS AND OTHER SPECIES IN OREGON

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Marbled Murrelet (*Brachyramphus marmoratus*) populations have undergone a long-term decline in the Pacific Northwest, and the species is currently listed as Threatened under the federal Endangered Species Act. This elusive seabird forages in nearshore waters and nests in mature forests, yet adult mortality is poorly understood. Raptors (e.g. Bald Eagles [*Haliaeetus leucocephalus;* hereafter "eagles"]) are known to prey on seabirds, and therefore have the potential to impact local populations. During the 2017-2019 breeding seasons, we captured 190 adult Murrelets off the central Oregon Coast and attached VHF-telemetry tags to monitor inland movements to nest sites and marine space use. Most Murrelet fatalities we documented (51.5%, 17 of 33) were suspected to be caused by raptor predation based on a combination of physical damage to carcasses (e.g., plucked feathers and flesh) and tracking of tags from missing Murrelets to areas near raptor perch sites and nests. In 2019, tags from four out of six confirmed fatalities were tracked to four distinct eagle nests, prompting us to collect prey remains in August of 2019. We found that 82.1% of the prey items recovered in and adjacent to eagle nests were identified to alcids (96% Common Murres [*Uria aalge*]) followed by shellfish (3%), fish (3%), and mammals (1%). Given marked increases in coastal eagle populations and direct observations of eagles taking adult Common Murres at colonial nest sites, we hypothesize that raptor predation pressure on Murrelets and other seabirds along the Oregon Coast may be substantial and that additional research is needed to better understand the dynamics of "seabird-raptor" interactions and their impact on seabird demography.

SHALLOW DIVE SEABIRD FORAGING DETECTION USING TRI-AXIAL ACCELERATION

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Seabirds typically cover wide ranges of ocean, foraging in transient locations where prey amass. Decision making in these birds is therefore vital to avoid wasting considerable energy travelling great distances with little to no benefit. Isolating foraging behavior is key to understand these decisions. Behavior identification using a combination of acceleration and depth data from on-board data loggers has been used to good effect in mid to deep diving seabirds. However shallow diving seabirds produce much reduced signals than deeper diving species, with depth data of little use given the minimal depths typically reached. High resolution acceleration may contain enough information to reliably identify foraging in even the shallowest diving birds. Data loggers can now record such acceleration, coupled with other sensors used to validate behavior. In this study, streaked shearwaters (*Calonectris leucomelas*), a known shallow-diving seabird nesting in the northeast of Japan, were attached with two tags, either a video and acceleration tag (Little Leonardo), or an acceleration and GPS tag (TechnoSmart). Four behaviors were identified from video data: flight, dive, inter-dive and pre-flight take-off. Video footage of prey capture during some dives were recorded. Acceleration characteristics for each behavior were used in a deductive method capable of isolating foraging behavior as validated by concurrent video footage. Results of the acceleration analysis method were compared to flight speeds of GPS and acceleration tags and visually verified. Successfully extracting fine-scale foraging behavior will allow further analysis of the characteristics of movement in this species and the decision-making process in foraging seabirds.

WHEN SEABIRDS BECOME TERRESTRIAL: RECENT CHANGES IN THE FORAGING ECOLOGY OF LESSER BLACK-BACKED GULLS IN THE NORTH SEA

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Lesser Black-backed Gulls (*Larus fuscus*) have shown a spectacular population increase at the German North Sea coast from just 100 breeding pairs in the 1970s to more than 40,000 pairs around 2010, with numbers having reached a plateau in recent years. Numbers at sea, derived from aerial and ship-based surveys, showed the same pattern of increase until around 2010, when numbers at sea started to decrease. This coincides with a remarkable change in the diet composition as determined from analyses of several thousand pellets collected during incubation and chick-rearing over a period of almost 30 years. While the diet in the 1990s consisted almost exclusively of marine food items such as fish and crabs, terrestrial food items (mostly earthworms and insects) became important components of the diet since the mid-2000s. Nowadays, proportions of marine and terrestrial food items are roughly of similar

importance. Proportions of fish in the diet, i.e. pelagic shoaling fish and discards from commercial fisheries, have steeply decreased, while swimming crabs occur more frequently in food remains, mirroring the observed population trends in these prey resources. Terrestrial habitats also showed important changes: corn fields almost doubled in area size from the late 1990s to the early 2010s due to the promoted use of biomass as a renewable energy source, and offer gulls direct access to the soil much longer in the breeding period than most other vegetation types. We conclude that food availability at sea has generally decreased, while the foraging options on land have improved. The strong increase in breeding numbers has led to increased intraspecific competition, enhancing diversification in the gulls' nutrition.

LARGE-SCALE IMPLEMENTATION OF OFFSHORE WIND ENERGY CONFLICTS WITH MARINE CONSERVATION GOALS IN THE SOUTHERN NORTH SEA, EUROPE

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Offshore wind energy use has been established in the German sector of the North Sea, Europe, within the last decade. Currently, 19 wind farms are in use, 3 under construction and another 4 have been consented. The current climate debate asks for further huge increases in energy generation by this type of renewable energy source.
We evaluate the possible impact of offshore wind farms on seabirds by two different approaches. First, data on seabirds were collected from research projects, from the German marine biodiversity monitoring as well as from construction and operational wind farm monitoring obligations. Very recent digital, aerial and ship-based post-construction survey data show huge and widespread displacement from the wind farm sites in Red-throated Loons (Gavia stellata), the species with the highest conservation concern in German North Sea waters.
Second, several seabird species breeding on the offshore island Helgoland were tracked by GPS tags. Common Murres (Uria aalge) showed clear avoidance of wind farms, while Northern Gannets (Morus bassanus) and Black-legged Kittiwakes (Rissa tridactyla) exhibited individually varying responses with a clear trend of being displaced from wind farms.
Consequences for marine conservation and spatial planning are shown based on these recent findings.

SHORT-TAILED ALBATROSS (PHOEBASTRIA ALBATRUS) RECENT AND HISTORICAL NESTING ACTIVITY AT MIDWAY ATOLL NATIONAL WILDLIFE REFUGE

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Short-tailed Albatross (*Phoebastria albatrus*) were driven to the brink of extinction in the 1930's by feather hunters and volcanic eruptions, leaving Torishima Island, Japan as their last breeding colony. Early data collected from Midway Atoll was from incidental sightings and photographs by resident and visiting biologists. In more recent years game cameras have been set up to record the egg laying, incubation and chick hatching dates. Since 1938, a total of 24-27 individual Short-tailed Albatross have been documented on the atoll's Eastern and Sand Islands. The first successful nesting in the Central Pacific occurred on Eastern Island in 2011, with a pair fledging 3 chicks between 2011 and 2014. A new pair was formed in the 2016-2017 season by a male and female previously seen separately on Sand Island (every year since 2006 and 2011 respectively). The next season they incubated an egg laid by a neighboring black-footed albatross and successfully fledged the chick. The following year, the pair produced their own egg and fledged the first documented Short-tailed Albatross chick from Sand Island in 2019. Comparisons with colony data from Torishima suggest that egg-laying dates may be later at Midway Atoll than in the Japanese islands. Decoys and Audio callers will continue to be used to attract more breeding pairs to the Atoll.

CHANGES IN THE FORAGING HABITS OF COMMON MURRES (URIA AALGE) THROUGHOUT THE BREEDING SEASON AT SOUTHEAST FARALLON ISLAND.

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Tracking studies have revealed the foraging habits of many seabird species, yet most have not examined how foraging behavior changes over the course of a breeding season. Some diving species exhibit differences in their foraging habits and ranges throughout the breeding season, performing longer trips and shorter dives during the incubation phase suggesting that such differences were due to energetic and temporal demands, environmental conditions, and/or prey distribution. Here, we examined the foraging behavior of breeding common murres (*Uria aalge*) at the Farallon Islands in Central California. Murres were studied during the incubation (n = 11) and chick-brooding phases (n = 8) in June-July 2019. Individuals were captured in the colony and equipped with a 25 g GPS logger that sampled at 2 min intervals. Overall, a total of 46 foraging trips were obtained showing significantly different patterns between each breeding phase. For example, incubating murres flew 2.3 times farther (132 ± 94.5 SD km) and trips were 2.9 times longer (31.9 ± 20.1 hours) than brooding murres. These preliminary results suggest that common murres alter their foraging behavior in response to changes in reproductive demands, which likely relates to the energetic constraints of the chick.

APPARENT INTRA-PAIR COORDINATION MAY ARISE THROUGH INDIVIDUAL BEHAVIOUR IN THE MANX SHEARWATER (PUFFINUS PUFFINUS)

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Seabirds often care for their offspring in remote breeding colonies where foraging sites may be unpredictable and distant. As a result, their young are at risk of being left unaccompanied for extended periods of time during their parents' foraging trips, leaving them vulnerable to predation. One way for this risk to be minimised is for individuals to coordinate parental care duties with their partner. The degree of flexibility and coordination that pairs are capable of has been a subject of much interest, and many seabirds are now known to coordinate their care. However, the mechanisms used to achieve coordination are largely unknown. To resolve this, we physically handicapped Manx shearwaters (*Puffinus puffinus*) to reduce their foraging efficiency, forcing them to choose between an extended foraging trip or to return to the nest before they have fully recovered their condition. We found that handicapped parents took significantly longer foraging trips than normal, to which their partner responded by lengthening their incubation stint. But lengthy incubation stints appear to come at a cost with these individuals subsequently embarking on longer foraging trips once their partner returned. These results suggest that coordination emerges from a simple, individual-centric rule where foraging birds stay at sea for as long as it takes them to recover their condition, and where incubating birds remain at the nest until their partner returns. Consequently, apparently coordinated behaviour can arise without the need for explicit communication.

SEABIRD INTERACTIONS WITH THE CATCHER-PROCESSOR TRAWL FLEET TARGETING PACIFIC HAKE OFF THE U.S. WEST COAST

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Minimizing incidental bycatch of seabirds in trawl fisheries continues to be a challenge to global seabird conservation. Trawl fishing vessels that process fish at sea attract seabirds, putting them at risk for collision with cables connected to the net. Additionally, fishermen increasingly monitor catch in real time to avoid sensitive fish species and these technologies require additional cables which can pose risks to seabirds. Interactions can result in injury or death, but dead seabirds are rarely documented by fisheries observers, resulting in uncertain bycatch estimates. Results from a recent study (2016-2018) raised concerns about the extent of this cryptic seabird bycatch in catcher-processor trawl fisheries for Pacific hake (*Merluccius productus*) on the U.S. West Coast. In a collaborative research partnership with

industry, we deployed at-sea seabird monitors on hake catcher-processor vessels during the spring (13 May – 18 June, 2019) and fall (11 Sept – 25 Nov, 2019) hake seasons. During 1,130 hours of observations, we documented the frequency of seabird interactions (hard and light strikes) with trawl fishing gear during all phases of fishing operations (setting, towing and retrieving nets) and assessed interaction outcome (bird mortality, injury, or not harmed). We also investigated the feasibility and effectiveness of mitigation to reduce interactions with seabirds (warp booms, water cannon, and paired streamer lines stabilized with troll boards). These efforts build on a history of successful collaboration with North Pacific fisheries to better understand and minimize the extent of seabird interactions using practical, cost effective, and scientifically proven strategies.

ALEUTIAN TERN COLONY ABUNDANCE IN ALASKA BASED ON UNMANNED AERIAL SYSTEMS (UAS) PHOTOGRAPHY

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The Aleutian Tern (ALTE: Onychoprion aleuticus) is an uncommon seabird that nests in coastal areas of Alaska and Russia. Renner et al. (2015) estimated a population decline of 8.1% annually since 1960 at known colonies in Alaska. Ground-based ALTE counts are problematic because tall vegetation may obscure nests and observers may disturb nesting birds. As part of an effort to develop a statewide monitoring program, we tested the use of low-altitude photography obtained from unmanned aerial vehicles (UAV) as a method to estimate abundance at individual nest colonies. In 2018 & 2019, we used UAVs to photograph terns at colonies in Yakutat, Kodiak, and Kenai, AK from altitudes of 15 m above ground. No adverse effects on tern behavior were apparent during flights at this elevation. We developed a semi-automated aerial image detection system to count Aleutian and Arctic Terns (Sterna paradisaea), frequently nesting in mixed colonies, based on Deep Learning, using a convoluted neural network. We measured tern density after computing photo footprint size. We discuss the use of drones, identification of terns in UAV photographs, and the results from the semi-automated counting method across several colonies. Our results suggest that drones can be an effective tool in monitoring sensitive terns at nest colonies of various sizes, landcover types, etc. More broadly, our method demonstrates the utility of UAVs in surveying wildlife in field conditions where human survey is unreliable or not feasible.

A SEABIRD-CENTERED EDUCATION PROJECT ON THE OREGON COAST

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On February 4, 1999, the marine vessel New Carissa ran aground near Coos Bay, Oregon. After several days in heavy surf, the ship broke apart releasing 140,000 gallons of fuel into the marine environment. Total mortality was estimated at 2,465 seabirds, primarily Cassin's Auklet (*Ptychoramphus aleuticus*), rhinoceros auklet (*Cerorhinca monocerata*), surf scoter (*Melanitta perspicillata*), white-winged scoter (*Melanitta fusca*), northern fulmar (*Fulmarus glacialis*), Brandt's cormorant (*Phalacrocorax penicillatus*), black-legged kittiwake (*Rissa tridactyla*) and common murre (*Uria aalge*) as well as 672 shorebirds, primarily sanderlings (*Calidris alba*). A portion of the $28M settlement included funds to provide public education on the biology and conservation needs of seabirds and other marine wildlife along the Oregon coast. The natural resource trustees wanted to create a suite of projects to provide an engaging public learning experience, demonstrating what individuals can do to help protect seabirds. Projects included: 1) 66 unique, award-winning interpretive panels located at 24 sites along the Oregon coast, 2) new educational exhibits at a major visitor center near Brookings, OR, 3) a smartphone app bio facts and a GPS based game, and 4) educational signs asking visitors to stay off nearshore rocks and to not feed gulls and other potential predators near seabird colonies.

THE MIDDLETON ISLAND BIOLOGICAL STATION: A UNIQUE FACILITY FOR ECOSYSTEM RESEARCH IN THE GULF OF ALASKA

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On Middleton Island in the northern Gulf of Alaska is a marine field station unlike any other in the world. Research and monitoring conducted there since 1978 is furnishing data relevant to marine ecosystem management in the Gulf and possibly the northeastern Pacific generally. The Middleton Island Air Force Base—a decommissioned Cold War facility—was purchased from the federal government in 1966 by a consortium of Alaska businessmen. In the 1980s kittiwakes began nesting on the 70-foot tower that supported the main radar in USAF days, and biologists capitalized on the birds' unusual behavior by adding wooden ledges and panes of one-way mirror glass for the observation and manipulation of birds and nests from inside the building. The result today is a controlled breeding habitat unmatched anywhere in the world. Despite the success of the tower colony as a research facility, its future remained in doubt as long as the Air Force buildings and surrounding acreage belonged to private landowners with no particular stake in their wildlife or research values. When government agencies declined to re-acquire the property or maintain it as a research facility, biologists familiar with the site established the Institute for Seabird Research and Conservation (ISRC) in 2009 to effect such protections. The property was acquired by the Institute in November 2011, but much remains to be done to ensure the long-term viability and full development of the Middleton Island Marine Biological Station. Ecosystem monitoring on Middleton is furnishing timely information with important implications for oceanic birds, sea lions, salmon, and other species of major significance in Alaska's marine ecosystems. The annual response of birds to supplemental feeding on the tower provides a singular and highly effective measure of food availability to upper trophic-level predators, while the

accessibility of several species for repeated capture and handling encourages experiments that would be difficult or impossible to accomplish elsewhere. As such, the Middleton station is postioned to play a signficant future role given its unmatched historical record and ability to furnish sensitive indicators during current events such as marine heatwaves and seabird die-offs.

NOAA FISHERIES' NATIONAL SEABIRD PROGRAM: ADVANCING CONSERVATION, SUSTAINABLE FISHERIES, AND ECOSYSTEM-BASED MANAGEMENT

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Since the early 1980s, NOAA Fisheries has been monitoring and mitigating for seabird bycatch. In 2001, the agency formed the National Seabird Program (NSP) to coordinate seabird protection, and today it is a cross-cutting group of managers and scientists working domestically and internationally to protect and conserve seabirds. The program's activities are guided by statutes and agency priorities which form the basis for NSP's two key goals: 1) Monitor and mitigate seabird bycatch – NOAA Fisheries is responsible for bycatch in U.S. fisheries and supports bycatch reduction associated with non-U.S. fisheries, and 2) Promote seabirds as ecosystem indicators. As highly migratory, near-apex predators, seabirds integrate across trophic levels, space, and time, are easy to detect and identify, can be surveyed over various spatial scales, and are responsive to environmental change. In 2019, NSP finalized a five-year strategic plan to promote awareness and value of seabirds, foster collaboration, and coordinate and direct resources to accomplish its objectives. In practice, the program's approach to achieving its goals has been supporting field and laboratory research, ensuring our representation on working groups and steering committees within and external to NOAA Fisheries, and partnering with NOAA Offices, FMCs, States, and other Federal agencies. Other actions are coordinating and providing seabird expertise for policy and management decisions, conducting research, fieldwork, and outreach through agency reports and peer-reviewed publications. Seabirds are the world's most threatened bird group, and NOAA Fisheries' National Seabird Program continues to support seabird conservation both nationally and internationally.

SEABIRD SENSORY ECOLOGY, MORPHOLOGY AND BYCATCH

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A sensory trap deceives an animal, initiating a potentially harmful behavioral response towards a stimuli normally associated with positive outcome. Seabirds are prone and attracted to sensory traps due to their unique and highly adapted sensory ecologies. One possible seabird sensory trap are fishing vessels - bycatch causes hundreds of thousands of seabird mortalities annually. I used the literature to examine the sensory ecologies and morphologies of seabirds caught in bycatch around New Zealand. I then chose six seabird species that co-occur in the same habitat near Auckland, but have very different bycatch rates. I explored in detail their skeletal morphologies and sensory systems using morphometric measurements of museum seabird specimens and 3D skull endocasts via Micro CT scans. In my literature review, I found that diet (especially krill feeding) and a larger body size correlated with higher bycatch risk. The detailed measurements of my 6 case study species also suggest a role for larger body size, but also reveal a significant effect of skull length, nostril socket volume and eye socket volume, even when adjusted for body size. The sensory ecology of seabirds may be underappreciated but is likely a critical factor affecting their bycatch risk, providing new options for mitigating this issue.

CONFIRMATION OF A LINK BETWEEN WINTER DISTRIBUTION AND POPULATION GENETIC STRUCTURE IN THE RHINOCEROS AUKLET

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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 distinct nonbreeding areas (or seasons) are expected to exhibit structuring. We tested this hypothesis in the Rhinoceros Auklet (*Cerorhinca monocerata*) by deploying 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 collecting blood samples on all colonies. We detected significant genetic structuring, especially between the eastern and western Pacific, but also a complex pattern within both groups. The inter-colony and individual variation in the migratory behavior of Rhinoceros Auklets was marked, and there was no support for structure to have arisen as a result of isolation by distance. As predicted, there was a significant negative correlation between population differentiation (F'_{ST}) and the extent of spatial overlap between pairs of breeding colonies.

MICE TO EAT YOU: UNCOVERING THE DIET OF INVASIVE HOUSE MICE

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Midway Atoll National Wildlife Refuge (MANWR) is the world's largest albatross colony and provides globally significant breeding grounds for over 20 avian species totaling more than 3 million birds. Since 2015, invasive house mice (*Mus musculus*) have attacked and depredated hundreds of nesting adult albatross. Mouse eradication on MANWR is planned for the summer of 2020, but the broader ecosystem-level effects of this invasive species are largely unknown. Here, we investigate mouse diet in order to infer ecological impacts of mice and predict potential ecosystem response to mouse eradication. We combined eDNA metabarcoding/next-generation sequencing (NGS) and stable isotope analysis to construct house mouse diet composition. We collected (paired) fecal and hair samples from 318 mice across MANWR's Sand Island from April 2018 to May 2019. Mice were trapped approximately every 8 weeks among four distinct habitat types, so as to provide insight into temporal and spatial shifts. Preliminary results from NGS indicate that plant material (DNA) is absent or too rare to amplify from mouse fecal pellets; however, prey DNA in mouse fecal samples does include that of vertebrates (specifically seabirds) and invertebrates. Stable isotope analysis also reveals that mice have very high trophic positions, greater than that of Laysan Albatross (*Phoebastria immutabilis*) by more than 3%. Mouse trophic position does not vary seasonally, nor by habitat. Mice may preferentially consume seabird sources (likely through scavenging or preying on scavengers) for most of their diet; in turn, mouse diet could have implications for eradication operations in regard to bait palatability and availability of alternate food sources.

ONLINE SEABIRD COLONY MAPPER FOR THE US FISH AND WILDLIFE SERVICE'S PACIFIC SEABIRD PROGRAM

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The USFWS created the Pacific Seabird Program in 2017 to coordinate seabird monitoring in Alaska, Washington, Oregon, California, Hawaii and the US Tropical Pacific. A data manager was hired in 2017 and began assembling seabird colony locations and data for the focus area. Data has been compiled, and an online mapper was created using ESRI's ArcGIS Online. Individual colony sites are represented by points and in some cases, lines, representing stretches of surveyed coastline. Each colony has a unique SITECODE and a SITENAME. Data associated with the colonies includes species present, date surveyed, estimated breeding population, and associated survey metadata. While other seabird colony mappers have been proposed and implemented by private consultants, budget shortfalls have prevented their

continued update and maintenance. The USFWS has a contract with ESRI to provide GIS software and online GIS storage, which allows us to provide a mapper at no additional cost beyond our annual maintenance fee. Future work will focus on simple procedures to allow for annual updates to the dataset by cooperators.

DETECTING SEABIRDS AND MARINE MAMMALS FROM DIGITAL AERIAL IMAGERY OF THE PACIFIC OUTER CONTINENTAL SHELF OFF CENTRAL AND SOUTHERN CALIFORNIA, USA

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The U.S. Geological Survey's Western Ecological Research Center, with support from the Bureau of Ocean Energy Management, is conducting aerial photographic surveys of the Pacific Outer Continental Shelf (POCS) off central and southern California during different oceanographic seasons and migratory periods from 2018–2021. Survey transects provide broad spatial coverage and generate an archivable record of ~100,000 high-resolution digital images with associated sensor data each season. Application of new analytic methods are required to process and analyze this volume of data. While the field of machine learning is rapidly evolving, off-the-shelf technology does not yet exist to detect, classify, and count objects of interest from at-sea aerial survey imagery. One of the major obstacles is a lack of annotated training data (i.e. images with species identified) needed to "teach" algorithms what to look for. This project is developing image-quality metrics, an annotation tool, and a library of human-annotated training data with linked database to help overcome this challenge. Along with these tools, errors including false negatives and false positives will be evaluated. Ultimately, the goal is to develop a machine learning pipeline to ingest images, detect images that contain objects of interest, then classify and enumerate seabirds and marine mammals to the lowest taxonomic group possible. In the future, results from 2018–21 will be compared to human-observer-based surveys from low-flying aircraft conducted historically (1980's and 1999-2002) in this region. These techniques have potential to be used for long-term monitoring (pre- and post-construction) of offshore wind projects in the POCS.

PREDICTING HABITAT SUITABILITY FOR A CRITICAL PREY SPECIES IN THE SALISH SEA, PACIFIC SAND LANCE

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Pacific sand lance (*Ammodytes personatus)* is a critical prey for vertebrate predators such as salmon, seabirds, and seals in the nearshore coastal ecosystems of the Pacific northwest. Pacific sand lance (sand lance) lack a swim bladder and depend on coarse, well-oxygenated sandy substrates in shallow water to bury in when resting. In British Columbia suitable burying habitat for sand lance remains largely unmapped, little is known about the population abundance, distribution, and spawning locations, and human activities and developments in these habitats have been unregulated. This project proposes to develop an objective assessment framework to assist with managing anthropogenic threats to sand lance habitat. As there is currently no such guidance, habitat managers and project stakeholders are unable to effectively account for, identify, and mitigate potential impacts of activities on sand lance burying habitats. This project will (1) predict habitat suitability for sand lance using a combination of existing survey records, and the collection of additional data on sand lance use of sub-tidal habitats*;* (2) conduct a review of historical, existing, and proposed industrial project locations and activities with the potential to impact sand lance and sand lance habitat; and (3) in collaboration with stakeholders, develop an assessment framework to help managers evaluate possible impacts on sand lance burying habitats. Protection of forage fish and their habitats through improved sustainable coastal ecosystem management practices will ensure the health of forage fish populations, their dependent predators and the ecosystem as a whole.

APPLICATION OF UNMANNED AERIAL VEHICLES AND AUTO IDENTIFICATION TECHNIQUES ON SEABIRD COLONY MONITORING IN MATSU ARCHIPELAGO, TAIWAN

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The critically endangered Chinese Crested Tern *Thalasseus bernsteini* (CCT) nests sympatrically with the Great Crested Tern(GCT; *Thalasseus bergii*) among seven protected islands within the Matsu archipelago, Taiwan. To minimize disturbances during breeding season, we used Unmanned Aerial Vehicles (UAVs) to locate CCT and GCT nests and built digital surface models of the breeding island in 2017 and 2019, separately. We used generalized linear models to distinguish the effects of elevation, slope and vegetation coverage on CCT's and GCT's nest distribution patterns. The model indicated that GCTs prefer to nest at high (> 13 m above high tide line) and flat (slope < 25°) habitats with less vegetation covered (< 22%), while CCTs prefer to nest within areas with high nest density of GCTs. In addition, we developed an auto identification technique to evaluate the population size of GCTs and CCTs in the colony. We used 663 pictures for artificial intelligence training and found 285 pictures to be validated as useful. Our results demonstrate that UAVs can be important and useful for improving the accuracy and efficiency of seabirds monitoring for inaccessible islands.

SATTLITE TRACKING REVEALED IMPORTANT HABITATS FOR GREATER CREATED TERN (*THALASSEUS BERGII*) IN SOUTH-EAST ASIA

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Greater Created Tern (GCT; *Thalasseus bergii*) was a common near-shore seabird in west Pacific Ocean region. Matsu, Penghu, Wuzhishan and Jiushan Archipelagos in Taiwan and Mainland China are the most stable areas confirmed to have a breeding population but little is known about its stopover and wintering sites. From 2016 to 2018, we tracked 19 GCTs tagged with satellite transmitters in Matsu and Penghu Archipelagos. We not only analyzed their migration routes but also habitat preferences of breeding and wintering sites . The results show that there are two migration routes for wintering: one group traveled along the coast of China and then moved southwestward to Vietnam, Thailand, and Myanmar while the other group moved southward to Philippine. We also found that GCTs preferred to forage among shallow and cool water areas with high chlorophyll concentration near their colonies and/or shoreline during breeding and wintering seasons although there is no significant preference during migration seasons. In addition, our results show that GCT's stopovers and wintering sites were highly overlapped with protected areas in Thailand, Myanmar, Vietnam and Cambodia. We suggest that these marine and wetland protected areas were critical to GCTs in South-East Asia. The migration system of GCTs offers an extraordinary possibility to understand the importance of cross-border seabird conservation.

SPECIES IDENTIFICATION BY DEEP LEARNING WITH BYCATCH SEABIRD PHOTO TAKEN IN PELAGIC LONGLINE SCIENTIFIC OBSERVER RESEARCH

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For assessment of the ecological impact of fisheries, data corrected from scientific observer program provide catch and bycatch information of fisheries operations. So far, the photograph of the bycatch species taken by the observer was identified by scientists or professional persons. Recently, machine learning algorism was remarkably developed. Application of that technique to image analysis for species identification would contribute to promoting the accuracy of large data. Also, new species identification key might be found from the image analysis. In this study, species identification by image analysis was examined based on observer data from pelagic longline fisheries in Japan. Also, important parts for deep learning and existing species identification key was compared. Convolutional Neural Network was used for image analysis. Photo-image data of 26 species albatrosses and petrels in the southern hemisphere which was taken by the scientific observer were used and the accuracy of validation was calculated. Important parts for the image analysis was investigated by Grad CAM. VGG 16 model already learned by the imagenet, which transfer learning from the C4 layer was done, indicated that 12 species from 26 species were over 70% accuracy. The species having unique body-color patterns were especially higher accuracy whereas the species whom human scientists cannot identify from the photo were lower

accuracy. Important body parts for deep learning were, though variety, similar to the existing key such as whole body, face, and underwing parts. This result indicates that this would be applicable to the primary sorting of species identifications of large photo data, though could not find a new identification key.

EFFECTS OF MARINE ANTHROPOGENIC ACTIVITIES ON THE BEHAVIORAL RESPONSES OF HUMBOLDT PENGUINS IN PERU

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Humboldt penguins (*Spheniscus humboldti*) are listed as Endangered by the IUCN due to their low numbers and reduced habitat in comparison to historical records. We aimed to examine the effects of anthropogenic activities on changes of behavioral responses of mixed groups of adult/juvenile Humboldt penguins on Asia and Pachacamac islands, central Peru in 2018-2019. Anthropogenic activities included jet skiing, kayaking, tourism from boats (recreational) and compressor-diving and fishing with string in boats (harvesting). The effects of these activities were measured at distances from 20 to 100 m from penguins resting on the beaches or boulders on the shore. A logistic regression analysis revealed that both the type of activity and the approach distance to the penguins had the strongest significant effects on penguin reactions. At 50-m from the shore all activities led to > 50% of penguin reaction occurrence, and at 30-m, > 80% of penguins reacted. At 100–m distance from the shore, jet skiing were the most disturbing activity with 80 % of penguin reaction occurrence. The results of this study are of particular interest for conservation managers and Peruvian island administrators. Jet skiing for recreation should be forbidden around the islands. Zoning for tourist, recreation and fishing activities must be regulated and reinforced around the islands with Humboldt penguin colonies. This zoning needs to be based on the minimum approach distances probed to lead a behavioral change on Humboldt penguins.

SHORT-TAILED ALBATROSS TRANSLOCATION: HOW'D IT GO, AND WHAT'S UP NOW?

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Many in the seabird conservation community are familiar with the multi-year cooperative project between USFWS and Japan's Yamashina Institute for Ornithology. The endangered short-tailed albatross breeds only on Torishima, an active volcanic island. From 2008 to 2012 we moved month-old STAL chicks from an unstable slope on Torishima to a protected, non-volcanic (relatively flat) island, Mukojima, some 350 km south of Torishima. We then became chick parents, feeding them nearly daily until they fledged, at 3-4 months of age. With parental pride, we note our chick fledging success rate was very high. This presentation summarizes what has happened between that last translocation in 2012 and now, 2019. Have any of the fledglings returned to Mukojima? Have any tried to breed there? Attend this presentation to find out!

USING BAYESIAN MODELS TO ESTIMATE BLACK-FOOTED ALBATROSS BYCATCH IN THE U.S. WEST COAST DEMERSAL LONGLINE SABLEFISH FISHERY

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Rare events such as seabird bycatch in fisheries, can be challenging to estimate and sensitive to the methods used to make those estimates. While, traditional ratio estimators can result in biased estimates with large uncertainty, Bayesian methods have been shown to provide better precision and more stable inter-annual estimates than ratio estimators for marine mammal and sea turtle bycatch. The goal of this project is to develop more accurate and less volatile estimates of seabird bycatch. As a test case, we employed Bayesian time-series models to estimate black-footed albatross (Phoebastria nigripes) bycatch in the U.S. West Coast (WA, OR, CA) demersal longline fishery targeting sablefish (Anoplopoma fimbria). We present the results of Bayesian models comparing time-varying to constant bycatch rate, Poisson to negative-binomial bycatch distributions, and the inclusion of predictive covariates into these models. We used the data from randomly sampled seabird mortalities documented by fisheries observers during the period 2002 to 2018 in the Bayesian modeling exercise. Our results indicate that, a constant bycatch rate, a negative-binomial distribution, and a seasonal covariate improved bycatch estimates over other models. We compare the Bayesian estimates alongside estimates of bycatch using a ratio estimator and discuss the applicability of these results to other US West Coast groundfish fisheries and bird species.

REVISING THE MARINE RANGE OF THE ENDANGERED BLACK-CAPPED PETREL

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The Black-capped Petrel (*Pterodroma hasitata*) is an endangered seabird endemic to the western North Atlantic. The population is estimated at ~ 1,000 – 2,000 pairs nesting at four documented sites on Hispaniola, although to date only ~ 80 nests have been located. Most of our knowledge about habitat use at sea is based on observations during vessel-based surveys in the western north Atlantic conducted over the past 3 decades. Recently, however, the species has been the focus of satellite tagging from both nest- and sea-based deployments, and vessel-based surveys for seabirds have been conducted in the Gulf of Mexico. Each of these latter two data sets have added substantially to our understanding of the at-sea distribution of the species and therefore we have undertaken a reassessment of the marine range of the species. While previous range maps highlight waters west of the Gulf stream between approximately 30 – 36°N as primary use areas, our tracking data extend the use area north to ~ 41°N and east to ~ 50°W. Satellite tagged birds also foraged in the Caribbean Sea during chick-rearing, an area

not previously identified as commonly used. Lastly, vessel surveys (2017-2019) in the northern Gulf of Mexico in waters of the US EEZ have reported ~30 records of the species. Based on these data we suggest that the marine range of the species be expanded and that assessments of conservation threats be similarly reassessed to include these heretofore unreported use areas.

THE INFLUENCE OF PREY BIOMASS ON THE DIVING BEHAVIOR OF CASSIN'S AUKLETS DURING A DECADE OF VARIABLE REPRODUCTIVE SUCCESS

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The purpose of this study was to understand how inter-annual variations in krill levels influence the diving behavior of provisioning Cassin's auklets (*Ptychoramphus aleuticus*) and their reproductive success. We hypothesized that in years with lower krill biomass, the birds work harder to collect zooplankton for themselves and for their chicks. We predicted that in years with high levels of available krill, Cassin's auklets would make longer dives collecting abundant prey. We predicted that the shape of dives in years with more krill would be more U-shaped, with more time spent in the bottom portion of the dives (the feeding portion). We predicted that in low krill years Cassin's auklets would make more dives during diving bouts and more dives during foraging trips. From 2008 to 2017, we caught and affixed Time Depth Recorders (TDRs) to 133 Cassin's auklets breeding on the Farallon Islands for a total of 384 foraging trips during which they made a total of 107,552 dives. We measured krill biomass acoustically during oceanographic cruises carried out in the foraging area of the Cassin's auklets. We found that krill biomass from 2004 - 2017 explained much of the variation in Cassin's auklet productivity. In terms of diving effort, in years with a higher level of krill biomass, Cassin's auklets made longer dives and spent more time at the bottom of their dives. As predicted, Cassin's auklets made more dives during foraging trips in years with lower krill levels, however, we found that the number of dives in dive bouts was low during both very low and very high krill years. Our study reveals how diving behavior shifts under diverse foraging conditions and provides insight into the factors that affect reproductive success.

A REVIEW OF LAND-BASED BLACK-CAPPED PETREL CONSERVATION EFFORTS

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The Black-capped Petrel (*Pterodroma hasitata*) is a Caribbean island endemic breeder that has experienced significant population declines due to habitat loss, invasive species and direct persecution.

The species is listed as EN by the IUCN and is under review for listing as Threatened under the US ESA. At present, it is only known to nest on the island of Hispaniola, though evidence strongly suggests the species also breeds on Dominica. Limited data demonstrate variable reproductive success with failures due primarily to invasive species such as rats (*Rattus* spp.), cats (*Felis catus*) and mongoose (*Herpestes javanicus*). This, combined with evidence of adult mortality from a variety of sources near breeding colonies suggests the population continues to decline, a theory supported by recent radar surveys. The International Black-capped Petrel Conservation Group coordinates research and conservation action for the species. In 2018-2019, the IBPCG updated conservation actions, building on those outlined by Goetz et al. (2012) in the original conservation plan. The key strategies are to: 1) protect known nests and nesting areas; 2) identify new nesting sites and protect them, and 3) create new colonies in protected, predator free habitat. Predator control and reducing habitat degradation through community engagement are ongoing to protect known nesting areas, along with research to quantify threats and detail nesting biology. Radar, autonomous recording units, ground searches and satellite tracking are being used to find new nesting locations. A feasibility study for creating new nesting areas through translocation and social attraction is planned.

ASSESSING MISTNETTING AND ACOUSTIC MONITORING METHODS TO EVALUATE TRENDS AND VARIABILITY IN ASHY STORM-PETREL (*OCEANODROMA HOMOCHROA*) ABUNDANCE AND COLONY ATTENDANCE IN THE CALIFORNIA CHANNEL ISLANDS

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The California Channel Islands (CCI) provide essential nesting habitat for approximately half of the world's Ashy Storm-Petrel (*Oceanodroma homochroa*; ASSP) breeding population, but true abundance within the islands is not known. Mistnetting has been used to study ASSP presence and relative abundance at various locations throughout the CCI since 1974 (with standardized methods since 1994). Starting in 2014, acoustic monitors were also deployed at known or suspected ASSP colony locations for the same purposes. We analyzed mistnetting data (catch-per-unit-effort, CPUE) from 1994 – 2018 and acoustic monitoring data (call rates) from 2014 – 2018 to evaluate the use of both techniques for monitoring the CCI ASSP population. We compared CPUE and call rates at paired sites located throughout the CCI. We also explored the effects of abiotic factors (wave height and direction, wind speed and direction, moon illumination, cloud cover, etc.) on ASSP behavior and on our ability to detect presence (e.g. the effect of wave noise on acoustic detections). Both CPUE and call rates are limited by the degree to which they can detect individuals and the relationship between CPUE or call rates and true ASSP abundance is not well understood. However, we demonstrate the value of both techniques in detecting trends and patterns in abundance and explore whether comparison of both methods can

inform our ability to sample the meta-population across the range of ASSP. These results have implications for improved future monitoring of ASSP, and other species, within the CCI and beyond.

INTERNATIONAL COOPERATION TO REDUCE INTERACTIONS BETWEEN SEABIRDS AND FISHERIES

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One of the main threats to seabirds across the world is mortality associated with fishing. This threat is present both on the high seas and in the exclusive economic zones (EEZs) of many countries. Concerted effort is required by countries with fishing fleets on the high seas to address incidental mortality of seabirds. Each country with seabirds foraging in their EEZs should also take care to address this problem. A major existing mechanism to address the threats posed by fishing is the adoption by regional fishery management organizations (RFMOs) of conservation and management measures to mitigate seabird bycatch. Conservation and management measures (CMMs) are a product of a proposal made by one or more countries and then negotiated among members during RFMO annual meetings. Scientific review and advice are an essential part of the process. Many RFMOs have adopted measures related to bycatch in longline and trawl fisheries, although there is variation in the measures among the RFMOs. Some of these measures are in need of updating, based on recent information from at-sea trials and updated advice from the Agreement on the Conservation of Albatrosses and Petrels. The degree of compliance with the measures also remains a concern in some cases, and steps to improve the collection of information are necessary to understand the effectiveness of these CMMs.

A REVIEW OF SEABIRD BYCATCH AND MITIGATION EFFORTS IN ALASKA FISHERIES FROM 2010 THROUGH 2018

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Alaska has some of the most productive marine ecosystems in the world. Over 90% of U.S. breeding seabird populations, approximately 50 million birds from 39 species, use waters off Alaska during their life cycle. In waters off Alaska, hook-and-line fishing vessels use seabird avoidance measures to minimize seabird bycatch. However, 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. 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 the federal commercial groundfish and halibut fisheries off Alaska from 2010 through 2018 will be presented, along with recent findings concerning vessel-specific bycatch issues and possible solutions through targeted outreach.

SEABIRD SIGNALS IN A WARMING NORTHERN BERING-CHUKCHI SEA ECOSYSTEM

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The Northern Bering-Chukchi Sea ecosystem has been undergoing rapid physical and biological changes due to warming ocean temperatures. Using at-sea seabird surveys (>150,000 km of transects) we examined trends in seabird abundance and distribution in this region from 2007–2018. Planktivorous auklets (*Aethia spp*) which nest in the Northern Bering Sea (NBS), and short-tailed shearwaters (*Ardenna tenuirostris*), which nest in the southern hemisphere, were the most abundant species, but mainly piscivorous seabirds nest in the Chukchi Sea (CS). In the CS, cross-community Mantel correlations found spatial associations between planktivorous seabirds and zooplankton, but not between piscivorous seabirds and fishes, perhaps due to restricted foraging ranges of breeding birds. For most taxa, abundance varied more by location than among years, but in 2017-2018, with high ocean temperatures, abundance of some locally breeding seabird species were below long term means. At-sea densities indicated that, unlike in previous years, post-breeding planktivorous auklets did not migrate to the CS. Concurrently, biomass of small copepods was high in the NBS and the CS lacked large copepods. In contrast piscivorous murre (*Uria spp*) and black-legged kittiwake (*Rissa tridactyla*) densities at sea were below the long term mean in the NBS and nesting attempts were low, whereas abundance and productivity of these species was variable in the CS. Seabird mortality events also occurred throughout the region in 2017-2018. Detrimental effects were more prevalent in the NBS, but both planktivorous and piscivorous seabirds were affected throughout the NBS-CS region, suggesting impacts at multiple trophic levels.

ASSOCIATIONS BETWEEN ANNUAL CHANGES IN CHICK DIET AND BREEDING SUCCESS OF PIGEON GUILLEMOTS ON SOUTHEAST FARALLON ISLAND

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Annual variation in chick diet has been shown to have substantial effects on the fledging success of seabird species worldwide. The Pigeon Guillemot (*Cepphus columba*) is a near-shore benthic forager that provisions chicks with single-prey loads carried crosswise in the bill. Point Blue biologists have studied Pigeon Guillemot chick diet on Southeast Farallon Island for over thirty years by observing prey delivered to monitored breeding sites during the peak chick-rearing period, typically July through August. We used breeding success and diet data collected on the island between 1991 and 2019 to assess how annual changes in diet composition affected various breeding parameters such as productivity, hatching success, fledging success, and proportion of two-egg clutches. Preliminary results using linear models show a positive relationship between a higher proportion of rockfish delivered to chicks and mean annual productivity, and indicate a negative relationship between a higher proportion of both flatfish and sculpin to mean annual productivity. We plan to use additional models to describe and interpret the relationship between diet, breeding success, and environmental variables such as local sea surface temperature and upwelling indices. These analyses will contribute to a broader understanding of Pigeon Guillemot breeding biology on Southeast Farallon Island and offer insights into the composition and environmental sensitivity of near-shore forage fish populations present around the island.

I TWEET, THEREFORE I AM? FINDING YOUR VOICE IN THE AGE OF #SCICOMM

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There are many incentives for seabird scientists to communicate their work beyond scientific journal articles and conference presentations, including broadening the application of research to urgent conservation questions, engaging with researchers and stakeholders that lack access to academic channels, and avoiding the costs (both economic and ecological) of journals and conferences. For early-career scientists, strong scientific communication is also an important element of building their personal profiles in a job market that increasingly values citizen science and real-time public engagement. At the same time, communication is an entire field and a full-time job in and of itself, and there is no agreed-upon set of metrics for optimizing or evaluating science communication. Therefore, as scientists devote more time and resources to communication, it is important to ensure that these investments produce tangible results and do not detract from research objectives or become an unpaid second job. In this talk, I will highlight innovative communication efforts being led by early-career seabird scientists and others. The variety of strategies they employ suggests that there is no one-size-fits-all approach to science communication; rather, the most effective strategy is that which best matches an individual's or group's communication style and perspective with the target audience's interests, while accurately representing focal projects and findings. I will also highlight some strategies for creating science communication initiatives, defining clear goals and measurable outcomes, and developing or participating in innovative collaborations both within and outside the scientific realm.

SEASONAL HABITAT PARTITIONING BY SYMPATRIC SEA DUCK SPECIES IN EASTERN NORTH AMERICA

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Habitat partitioning, wherein species that occupy the same geographic areas select different locations or resources, is considered key to the coexistence of closely related sympatric species. However, partitioning can be difficult to observe in natural settings due to the complexity of measuring niche breadth across relevant environmental features. Sea ducks, which overlap extensively throughout the annual cycle and utilize similar marine areas during non-breeding, provide an opportunity to apply concepts of habitat partitioning to understand how multiple species can effectively coexist while utilizing shared resources. We collected satellite telemetry data on annual cycle movements of over 500 individual sea ducks of five species (Black Scoter, Surf Scoter, White-winged Scoter, Long-tailed Duck, and Common Eider) from throughout eastern North America and the Great Lakes. To investigate marine habitat partitioning during the non-breeding season, we applied a multivariate habitat selection analysis and compared selectivity values across species, seasons, and environmental characteristics. Our results suggest that niche separation and habitat selectivity are strongest during the post-breeding molt and migration period, when highly productive habitats are spatially limited and individual mobility is restricted. During winter, species show strong preferences for productive nearshore marine habitats, but also overlap extensively in shared habitat areas. Conversely, during spring migration, species show little habitat selectivity or partitioning, suggesting that factors other than environmental covariates are driving habitat use. We discuss the conservation implications of seasonal variation in habitat partitioning and selectivity, and identify key multi-species habitat features throughout the annual cycle.

COMPARING THE HABITAT USE AND FORAGING ECOLOGY OF GREAT BLACK-BACKED AND HERRING GULLS.

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While many members of the *Larus* genus have adapted to urban environments, the degree to which urban environments are utilized for foraging may vary greatly between species. To understand how the use of urban areas drives movement and foraging behavior in gulls, we compared differences in the habitat use and foraging ecology of herring gulls (*Larus argentatus;* HERG) and the lesser studied great black-backed gull (*Larus marinus;* GBBG). HERG are widely known to utilize urban environments, but evidence suggests that GBBG may primarily forage in marine environments. We collected data from a mixed-species breeding colony on Young's Island, NY, during the incubation period in spring 2019. We deployed GPS tags on 6 GBBG and 3 HERG with minimum and maximum deployment durations of 5 and12 days, respectively. Locations of foraging behavior were identified as areas of restricted search (ARS) using First Passage Time (FPT) analysis. We found that the proportion of foraging points within urban environments was significantly lower for GBBG than for HERG (Wilcoxon, p=0.01962). Site fidelity

and the average number of foraging trips per day were also significantly lower for GBBG than HERG (Wilcoxon, p=0.03887; p=0.0181). Our results exemplify the variation in urban adaptability that exists within the *Larus* genus and how urban vs. non-urban habitat use may influence foraging behavior. Ongoing work is using bulk stable isotope analyses of whole blood examining $\delta^{13}C$ and $\delta^{15}N$ values for tagged individuals to assess differences in isotopic signatures in relation to habitat use. Together, these analyses will provide further insight in to how habitat use and the use of urban environments impacts behavior, diet, and trophic ecology.

ASSESSING CASPIAN TERN COLONY DISPLACEMENT IN THE COLUMBIA PLATEAU REGION USING SATELLITE TELEMETRY

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Caspian terns (Hydroprogne caspia) are capable of long-distance breeding dispersal and colonization of new sites as nesting habitat is lost, and federal management plans have exploited those traits to reduce mortality from Caspian tern predation on threatened or endangered salmonid smolts in the Columbia River Basin. Beginning in 2014, management actions displaced the two largest breeding colonies of Caspian terns in the Columbia Plateau region with the intent of redistributing the birds to other colony sites throughout the Pacific Flyway. To assess the response to these colony displacements, we captured adult Caspian terns (n=76), tagged them with Platform Transmitting Terminal (PTT) tags, and subsequently tracked their movements using the ARGOS satellite telemetry system. Individuals were tracked an average of 705 days with some individuals tracked for more than four breeding seasons. We used Kernel Density Estimation to identify sites and areas where tagged terns nested and foraged. We also used mix-effects modeling and Akaike information criterion model selection to identify those factors that best explained variation in tern foraging habitat use, nest site use, and dispersal of tagged individuals. We found substantial group effects in nesting and foraging site use between the displaced colonies and some displaced terns made exploratory flights throughout the Flyway. However, PTT-tagged Caspian terns exhibited stronger than anticipated foraging and nest site fidelity to the Columbia Plateau region, which suggests that nesting or foraging opportunities elsewhere in the Flyway were insufficient to encourage substantial emigration following the loss of major colony sites on the Columbia Plateau.

BREEDING AND FORAGING ECOLOGY OF WESTERN GULLS NESTING IN DIFFERENT HABITATS ON THE CENTRAL OREGON COAST

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Along the Oregon coast western gulls (*Larus occidentalis*) nest in dense colonies or in small groups in moderate isolation. It is unclear if these nesting habitats influence reproductive success. In particular, pairs that nest on buildings are in close association with humans and may be prone to foraging on human refuse. To address this, we monitored reproductive success from three different study sites with different nesting habitats. Our study sites were located on the central Oregon coast at a relatively dense, established colony at 'Cleft-in-the-Rock' just north of Cape Perpetua (n = 40 monitored nests), isolated nests at a mixed-species colony at Yaquina Head Outstanding Natural Area (n = 19), and isolated nests around Newport, Oregon (n = 16). We also used GPS dataloggers to track individual foraging trips from 'Cleft-in-the-Rock' to determine foraging habitat and foraging range from the colony. In 2017, the overall nest success (percentage of all nests that fledged chicks) for pairs nesting in Newport and Cleft-in-the-Rock was 90%, and 44%, respectively. Our results for 2018 for all locations were different, with an overall nesting success for Newport of 75% and for Cleft-in-the-Rock of 78%. Birds from Cleft-in-the-Rock traveled up to 29 km away from their colony to forage, therefore human supported foraging habitats are within range of each breeding site. Thus, future work should focus on evaluating disturbance and predation between each site to continue to look into why these locations are so different and what contributes to changes in nest success.

RED-FOOTED BOOBIES ON MAUI: FIRST BREEDING ACCOUNT AND IMPLICATIONS FOR SEABIRD HABITAT PROTECTION ON HIGH HAWAIIAN ISLANDS

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Red-footed boobies ('Ā, *Sula sula*) breed on islands throughout tropical oceans. In Hawai'i, the majority of breeding pairs are on islands and atolls of the Papahanaumokuakea Marine National Monument (PMNM, approx. 8,000) followed by Kaua'i (1,800), Lehua (1,400), O'ahu (1,000) and Ka'ula (300). Red-footed boobies have been documented roosting on offshore islets of Maui, but no breeding activity has been documented to date. In 2018, over 100 birds were observed nesting primarily in Ironwood trees (*Casuarina equisetifolia*), Strawberry guava (*Psidium cattleianum*), and Christmasberry (*Schinus terebinthifolius*) on Pauwalu Point, Maui. We monitored the colony regularly throughout 2019 and mapped colony distribution using UAV digital imagery. Observations reveal asynchronous breeding, with high colony attendance throughout the year. We counted 462 nests and calculated a density of 140 nests/ha, likely underestimating colony size due to the limitations of aerial photography with the complexity of the vegetation community.
We suggest that the establishment of Red-footed boobies at Pauwalu Point may be an indication of habitat loss in PMNM. A large proportion of the population in the PMNM breed in Kānemiloha'i (French Frigate Shoals). In recent years, the islands of Kānemiloha'i have suffered severe impacts of

climate-driven events, including wave wash-overs and loss of vegetation and land area. Recognizing that seabirds are starting to emigrate from areas threatened by sea level rise, we must accelerate action to identify and protect high-quality habitat areas like Pauwalu Point for seabird colonies.

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

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We report on 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 are developing seasonal habitat-based spatial models of the at-sea distribution for 50+ species of marine birds throughout the US Pacific OCS. A statistical modeling framework will be used to estimate relationships between bird sighting data and a range of temporal and spatial environmental variables. The estimated relationships will then be used to predict the long-term spatial distribution of each species throughout the study area in each season. Bird sighting data come from multiple scientific survey programs and consist of at-sea counts of birds collected between 1980 and 2017 using boat-based and fixed-wing aerial transect survey methods. Environmental variables include 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 preliminary 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.

CHANGING FORAGING BEHAVIOR OF A SEABIRD PREDATOR IN COASTAL NEWFOUNDLAND UNDER SHIFTING PREY REGIMES

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Breeding seabirds respond to changes in prey availability within foraging ranges, leading to increased foraging effort and reduced reproductive success. Capelin (*Mallotus villosus*) is the primary forage fish species in the Northwest Atlantic. It migrates in high abundance into coastal regions of Newfoundland to spawn during the summer, changing the prey base from a lower abundance, sandlance-dominated (*Ammodytes* sp) state to a super abundant capelin-dominated state for marine predators. To investigate how seabird predators respond to these changes in prey availability, we tracked 18 chick-rearing razorbills (*Alca torda*) at an inshore colony during July- August 2019 and quantified foraging trip characteristics from individuals before (n=4) and after (n=14) inshore capelin arrival. We found that maximum distance from nest decreased from before the inshore arrival of capelin (20.7 ± 2.9 km) to after (5.5 ± 1.5 km), which was also reflected in total trip distance (before: 50.3 ± 26.6 km; after: 12.1 ± 3.2 km) along with other foraging trip characteristics (e.g., total trip duration). As the timing of inshore arrival of abundant spawning capelin has become more variable recently with increasingly unpredictable oceanographic conditions, these findings suggest that increased foraging effort by chick-rearing seabirds may result in lower reproductive output in years when capelin arrives inshore later in the chick-rearing period.

NEST SURVIVAL RATES OF ALEUTIAN TERNS AT PREDATOR-RICH MAINLAND AREAS IN SOUTHEAST ALASKA

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For almost two decades, Aleutian tern (*Onychoprion aleuticus*) and Arctic tern (*Sterna paradisea*) nesting has been monitored in various locations around Yakutat, Alaska. Beginning in 2017, multiple trail cameras have been deployed at nests in various colonies sites (Black Sand Spit, Lost River, and Italio) to monitor the attendance rate and nesting behaviors of Aleutian terns. We used the survival analysis package in R to model nest survival rates, and incorporated environmental covariates such as weather, temperature, and month. Results from 2017 and 2018 showed very low nest survival; averaging from 2-5 days of activity after deployment before nest failure, typically due to predation. In 2019, multiple successful nesting attempts were recorded at Black Sand Spit along with an increase in survival rate to an average of 7-9 days. Covariates showed little influence on nest survival, but the results illustrated the increase of the average survival of active monitored nests in 2019 compared to previous years.

USE OF SOCIAL SURVEYS TO ASSESS PUBLIC ATTITUDES TOWARDS SEABIRD CONSERVATION EFFORTS

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With increasing threats to seabirds from multiple anthropogenic impacts, there is a compelling need for local communities to support and engage in efforts to conserve many seabird populations. To engage communities meaningfully, their awareness and perceptions of species of conservation concern and conservation activities need to be understood. Réunion Island, Indian Ocean, is home to a diverse seabird community, including two endemic species of petrels, the Critically Endangered Mascarene Petrel (*Pseudobulweria aterrima*) and the Endangered Barau's Petrel (*Pterodroma baraui*). In this study, we assessed public knowledge of and attitudes towards the two endangered petrels and community-focused seabird conservation activities. We used two social surveys, one focused on recognition of Réunion seabirds and the long-term seabird rescue campaign on the island and the second on "Nuits Sans Lumiere," an annual month-long event to raise awareness of light impacts on seabirds. Ability to correctly identify species, endemic status and threats varied by species, with Barau's Petrel the best understood of the six focal species. In contrast, survey respondents were not as aware of the Critically Endangered Mascarene Petrel. Survey results indicate that impacts of light pollution on procellarid seabirds were generally well understood but that participation in the seabird rescue campaign is not widespread. Knowledge of and participation in "Nuits Sans Lumiere" varied by city, with Cilaos, the city closest to petrel breeding colonies, being the most engaged. The event was perceived as beneficial for the petrels and for reducing energy usage. These results will help guide future community outreach and policy-making efforts.

IMPROVED BREEDING SUCCESS AND FORAGING CONDITIONS IN THE GULF OF ALASKA FOLLOWING THE NORTH PACIFIC MARINE HEATWAVE

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Seabird reproductive success declined during and after the 2014-2016 marine heatwave (MHW) in the Gulf of Alaska (GOA), but there were signs of improvement by 2019. Because seabirds rely on lipid-rich prey resources, we hypothesized that these changes in breeding success were related to the availability of large nutritious forage fish in the system. Key forage fish species, including Pacific sand lance (*Ammodytes personatus*) and Pacific capelin (*Mallotus catervarius*), experienced changes in age structure and nutritional content during the MHW. For example, in Prince William Sound (PWS) spawning capelin were younger and smaller in 2013 compared to 2016, and total body energy content of age-1 sand lance in 2016 was reduced by 89% compared to cooler years. To identify regional differences in the demographic structure of forage fish populations, and to monitor indices of their recovery following the MHW in the GOA, we collected sand lance and capelin samples in PWS (2012-2019) and lower Cook Inlet (LCI, 2016-2019) for analyses of age, size, and energy content. Preliminary data suggests that the anomalously low growth of age-1 sand lance observed in PWS was less

pronounced in LCI during 2016, indicating that drivers of forage fish growth, such as lower trophic productivity and/or temperature, differed between the two regions. By 2019, sand lance and capelin age, size, and total energy indicated improved foraging conditions compared to 2016, and these observations were coincident with higher breeding success in seabirds. Monitoring changes in forage fish populations is critical to explaining the underpinnings of seabird ecology in changing marine ecosystems.

WHO'S HOME – NEST ATTENDANCE OF WESTERN GULLS NESTING IN TOWN AND IN THE COLONY

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Along the Oregon Coast, Western gulls' (*Larus occidentalis*) traditional nesting habitat has primarily been large off-shore rocks; however, in recent decades western gulls have begun to nest in urban habitats, taking up residence on the rooves of buildings and other structures in cities like Newport. To compare gull breeding biology in these habitats, two study sites were monitored for breeding success and parental attendance during the 2019 breeding season (May-August); an off-shore site called Cleft-of-the-Rock (n = 42 nests) and easily viewed rooftops in the city of Newport (n=20 nests). We hypothesized that western gulls nesting in Newport were likely to have higher breeding success and parental attendance, possibly due to anthropomorphic food sources. Attendance by at least one parent was not different between sites (Chi-squared test $p = 0.23$), but nests in Newport were more likely to have two parents attending instead of just one ($p < 0.001$). Trail cameras deployed at nests in Newport (n = 3) showed that pairs attended nests during the night. All nests at Cleft-of-the-Rock failed due to Bald Eagle (*Haliaeetus leucocephalus*) predation, while 69% of Newport nests reared at least one chick to 30 days. The difference between urban nesting and traditional habitat nesting gulls may lead to some insight about western gull's use of anthropomorphic landscapes and food sources, and the future of some seabirds with expected human expansion and reduced nesting habitat locations.

TRADE-OFFS BETWEEN LARGE MPAS AND MPA NETWORKS FOR PROTECTION OF SEABIRDS

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Marine protected areas (MPAs) can be used to safeguard marine biodiversity, however, tradeoffs exist when choosing where to place boundaries. Furthermore, large MPAs (LMPAs) are increasingly designated, however debate exists around their efficiency in contrast to networks of MPAs, though both LMPA and MPA networks have been suggested to effectively protect wide-ranging marine species. Here we use the optimization technique *prioritzr* to determine potential protection of MPAs in a multi-species context across different range sizes. We compare optimized networks versus a single LMPA across

different sized MPAs (1000 km^2, 10,000 km^2, 100,000km^2 and 1 million km^2) constrained to a single contiguous MPA, or multiple MPAs optimized for coverage of habitat. We used tracking data from four sympatric seabird species across breeding stages that represented localized, moderate and wide ranges to determine core habitat via utilization distributions. Overall, networks of MPAs out-performed single LMPAs of the same size in 12 of 14 instances where differences occurred for species with moderate and wide ranges, in some cases resulting in 92% more core habitat protected, equivalent to 403,000 km^2. However, LMPAs provided better protection of core habitat for localized species. When considering multi-species protection, a single LMPA covers a greater area (1,000 km^2 more area) than networks for localized species, which resulted in double the area protected for some species. We suggest that for wide-ranging species, MPA networks are more likely to optimize protection, but results may be highly species and context specific.

DOUBLE-CRESTED CORMORANT WESTERN POPULATION STATUS EVALUATION

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The U.S. Army Corps of Engineers developed the Double-crested Cormorant Management Plan and Final Environmental Impact Statement in 2015 to "…to reduce cormorant predation in the estuary to Base Period levels (no more than 5,380 to 5,939 nesting pairs on East Sand Island)." This reduction of predation on ESA-listed juvenile salmonids was called for in the National Marine Fisheries Services' 2014 Supplemental Federal Columbia River Power System Biological Opinion. The Management Plan includes coordination with the U.S. Fish and Wildlife Service and States to implement the Pacific Flyway Council Monitoring Strategy annually through 2019. A dual-frame methodology of sampling and analysis was used. Effort was concentrated on the largest, active colonies to ensure the majority of the population was sampled. The number of active nests counted at selected colonies provides an index to estimate the population. Surveys were completed to estimate peak number of breeding Double-crested Cormorants, through nest counts. The Service assembled and processed all colony information and derived estimates of the Western Population. The Astoria-Megler Bridge hosted the largest colony in 2019, with 3,542 breeding pairs. Other large colony complexes were in Washington, Idaho, and Utah. The observed 2019 peak for the East Sand Island colony was 350 breeding pairs. There was an overall shift in the size of colonies from larger to smaller. The 2014-2019 preliminary estimated population size ranged from 20,174 - 37,454 breeding pairs. The estimated population size was smaller in 2017 and 2019 compared to 2014, 2015, 2016 and 2018 ($p<0.01$). Estimates were higher than predicted by the Double-crested Cormorant Western Population Model.

MARBLED MURRELET AT-SEA POPULATION STATUS AND TRENDS IN THE NORTHWEST FOREST PLAN AREA, 2000-18.

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To evaluate the Northwest Forest Plan's effectiveness in conserving species associated with older forests, we monitored marbled murrelet (*Brachyramphus marmoratus*) populations annually from 2000 to 2018, in coastal waters off Washington, Oregon, and northern California. We divided these coastal waters into five geographic subareas corresponding to conservation zones established in the U.S. Fish and Wildlife Service's recovery plan for the murrelet. For each conservation zone, we counted murrelets from boats traveling along prescribed transect lines and used line transect or distance estimation methods to account for detectability. We estimated murrelet density, population size and associated trend for each conservation zone, and for all conservation zones combined. At the conservation zone scale, the population estimates from surveys in 2017 and 2018 ranged from 868 murrelets in Conservation Zone 5 to 8,574 murrelets in Conservation Zone 4. Density estimates ranged from to 0.9 murrelets per km^2 in Conservation Zone 5 to 7.4 murrelets per km^2 in Conservation Zone 4. In 2014, to reduce costs, a reduced sampling-effort design was implemented, where each conservation zone (exception Conservation Zone 5) was sampled every other year. Due to this reduced sampling effort, our Plan-wide area ("All Zones") estimate lags one year behind the most recent conservation zone scale estimates. Thus, we produced a Plan-wide population estimate for 2017, which was about 23,000 murrelets (95 percent confidence interval 18,300-27,600). Annual population estimates for the entire sampling period (2001-17) over the Plan area ranged from about 16,600 (2010) to 24,100 (2015) murrelets.

VISUAL PERCEPTION IN THE PELAGIC ENVIRONMENT: THE EYE OF THE WHITE-TAILED TROPICBIRD

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Physiological variations in the eyes of birds differ based on changes in ecological conditions. These variations in visual physiology have the potential to alter visual perception. White tailed tropicbirds (*Phaethon lepturus*) are diurnal, pelagic birds that forage by surface seizing and plunge diving from heights of up to 20m. The eyes of a juvenile white-tailed tropicbird were characterized using three methods: 1) Transmittance of ocular media (wavelengths of light that reach the retina) was measured with a spectrophotometer; 2) Microspectrophotometry measured the peak absorbance of oil droplets and associated visual pigments in cone and rod photoreceptors; and 3) Brightfield microscopy images of oil droplets across the whole retina quantified the density of different cones. Based on previous studies of marine birds, we predict *P. lepturus* have a retina with a prominent visual streak, and spectral filtering by oil droplets shifted towards the shorter wavelengths that dominate the pelagic environment. We will report the physiological results along with visual perception models to better understand how the unique ecological conditions of the pelagic environment can shape species-specific visual perception.

DEVELOPMENT OF AUTOMATED SEABIRD SPECIES RECOGNITION FOR USE IN ELECTRONIC MONITORING APPLICATIONS

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For two decades electronic monitoring (EM) pilot programs have tried to complement fisheries observer coverage. EM has not been able to match the timeliness and quality of programs such as the Alaska at sea reporting system, used for real-time quota management. Since we completed our first EM/seabird studies in 2002, computing capacity has grown exponentially (Moore's Law). Researchers now use computationally intensive algorithms to automate image identification. These new capabilities supported fish species recognition experiments in Alaskan waters. We capitalized on this work for seabirds by doing in-lab processing of various specimens retained for a Seabird Necropsy Program. Specimens were thawed and multiple poses taken. We primarily used procellarid species (albatross, fulmar, and shearwaters) but also included larid and alcid species. An eight channel multi-spectral camera chute that captured images reflecting light in narrow 50nm ranging from the ultraviolet to infrared spectrum was used to capture images for analysis with a convolutional neural network. We used 1837 images from 17 “classes” (species or species groups) for system training. We then used 213 images for testing species ID. The system achieved 100% accuracy for 6 species (including both albatross) where we had ample training photos. Where training images were few, lower accuracy

resulted. We further tested the system via a mock longline retrieval test. A stereo camera system that allows for precise 3d measurements of images was set up to emulate monitoring a longline retrieval. Analysis of these images is underway. Results to date support continued development of this system to improve our ability to monitor for seabird bycatch in many fisheries.

SEX-RELATED SURVIVAL, AGE-AT-FIRST BREEDING, AND BREEDING PROPENSITY OF ADÉLIE PENGUINS ON ROSS ISLAND, ANTARCTICA

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Sex-related variation is an important component of life-history traits in most organisms. Variation in population vital rates that drive population change can be associated with sex-related differences that reflect differences in basic biology and ecology of a species. However, for many monomorphic bird species (like many seabirds) which are difficult to sex visually, the effect of sex on demographics has not been well investigated. Known-age, known breeding history data on Adélie penguins from 1998 to 2017 where sex was also determined (1,964 birds) allowed us to evaluate the effect of sex on apparent survival, breeding propensity and movement rates among three breeding colonies on Ross Island, Antarctica. We used a multistate capture–mark–recapture maximum-likelihood model to estimate apparent survival ($\hat{S}$), recapture probability (p) and the probability of transitioning among breeding states and moving between colonies ($\hat{\psi}$; colony-specific non-juvenile pre-breeders, breeders and non-breeders). Survival rate varied in relation to breeding status and colony, but not sex. Pre-breeders had higher survival rates than breeders and non-breeders, but females had a higher probability of recruiting into the breeding population each year, and in general, bred at younger ages than males. Despite the lack of direct sex effects on survival, differences in breeding propensity and associated age of first reproduction between males and females, and lower survival rates of breeders compared to pre-breeders resulted in females having shorter lifespans than males. Consequently, understanding variation in survival rates relative to sex and life stage transitions is an important component of the population dynamics of long-lived birds.

ASEASONAL MORTALITY OF COMMON MURRE (*URIA AALGE*) DURING THE 2019 BREEDING SEASON IN NORTHERN CALIFORNIA.

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Beach Watch, a project of the Greater Farallones National Marine Sanctuary and the Greater Farallones Association, surveys have collected data of live and beachcast birds and mammals, twice monthly for 26 years. In 2019, 1,243 Beach Watch surveys were conducted between Manchester Beach in southern Mendocino County, CA, and Año Nuevo, in San Mateo County, CA. Beginning in April 2019, a large number of common murres (*Uria aalge*) were reported dead on northern California beaches. Data showed a higher than average encounter rate from April through June, typically a low deposition season. The two peaks of deposition in April and June were 600% higher than the 24-year average encounter rate for that season, 0.096 murres per km surveyed compared to 0.016 murres per km surveyed, respectively. During the months of April, May, and June, of the beachcast murres (n=577), 73% were adults (n= 423), 10% were second- year birds (n=58), and 15% were of unknown age (n=92). The 25-year average encounter rate for hatch year murres (year-round) was 0.134 chicks/km. In 2019, the encounter rate was 0.021 chicks/km, a decrease of 19%. The 2019 post-breeding (August – November) encounter rate was 0.307 murres/km (all age classes), 50% of the 25-year average rate for that time period. In 2019, there were very few hatch-year murres post-breeding, 0.044 chicks/km, 13% of average. This timing correlates with higher than normal sea surface temperatures, which occurred during the beginning of the breeding season of May 2019.

ESTIMATING SPACE SHARING BETWEEN SEABIRD, PINNIPED, AND HUMAN USE IN THE NORTHERN CALIFORNIA COAST

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Rocky coastlines incur high impacts from human use, but these places are also essential habitat for marine wildlife including seabirds and pinnipeds for breeding, resting, and social interaction. The potential of spatial and temporal overlap between humans and marine wildlife could lead to high risk of disturbance events. I investigated the relative risk of disturbance to 8 species of marine wildlife from varying types of human use to inform science-based cooperative management in areas where humans and wildlife overlap. I estimated space sharing between marine wildlife and human use using spatial overlap methods, specifically using the volume of intersection (VI) test statistic in Trinidad, California. Results of this project identified areas of varying levels of spatial overlap between seabirds, pinnipeds and varying types of human use (including consumptive and motorized activities). The species exhibiting the most space sharing with human use were Western Gulls (Larus occidentalis) with a VI score of .741 ± .058, while the least amount was Steller Sea Lions (Eumetopias jubatus) with a VI score of .0283 ± .0016. This project provided an assessment of the volume of intersection index as a spatial tool for identifying specific user groups for education, disturbance risk assessment, outreach and enforcement for marine wildlife protection.

BARFCODING: DNA-BARCODING OF BARF YIELDS INSIGHTS INTO SEABIRD FORAGING ECOLOGY

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Morphological identification of digested prey remains from a generalist forager can be a challenge, especially to species level. DNA techniques, whereby prey is sequenced and matched to large public nucleotide sequence databases, are increasingly being used to augment traditional morphological identification. To identify highly-digested prey items from Christmas (Chocolate) shearwater (*Puffinus nativitatis)* regurgitations from Kure Atoll, we used two DNA approaches that target the cytochrome *c* oxidase subunit I (COI) mitochondrial gene. First, we individually sequenced prey items from five regurgitations retrieved from birds tagged with time depth recorders in 2017, pairing dive behavior with diet. Second, we used "metabarfcoding" to bulk-process 92 water samples from regurgitations collected from 2009-2017 to get an overview of their diet. The prey items identified from tagged birds spanned a diverse range of taxa, including three reef-associated families, four pelagic-oceanic families, and a meso-pelagic family. The integration of diet and diving data provided insights into the vertical distribution of the prey, particularly regarding mesopelagic and nocturnal species. The metabarfcoding technique identified 94 unique taxa from 31 families of fish and squid. Overall, 45% percent of the families detected in the contemporary diet were previously documented in historical Chocolate shearwater diets from the Northwestern Hawaiian Islands dating back to the 1970s (Harrison *et al.* 1983). Rare species (occurring ≤ 5% of the samples) constituted 70% of the species richness. Our results indicate that the COI region is successful in identifying a wide range of taxa from highly digested seabird regurgitations.

NEST ATTENDANCE IN CALIFORNIA LEAST TERNS *(STERNULA ANTILLARUM BROWNI)*

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Nest attendance is a key factor in determining nest success. Consistent incubation can drive embryo health by regulating humidity, temperature, and egg turning, and increase colony attendance, thus reducing predation risk. External factors such as food availability or human and predator disturbance can also alter incubation behavior. To gauge nest attendance rates for California least terns (*Sternula antillarum browni*) in Coronado, California, we used time-lapse digital cameras (programmed for one photo per minute at 28 nests during incubation to document when both parents were off the nest. Using these data (1,030,173 pictures spanning three months: May-July 2019), we examined internal and external factors that may be driving nest attendance. We found evidence supporting the hypothesis that

absence of both parents during incubation and daylight is driven by foraging bouts. Both parents were absent only during daylight, left for longer foraging trips in the morning, and absences appear to be more common during specific tides (0.75-1m), known determinants of foraging access. Additionally, we found that cumulative time spent off the nest by both parents was greater for failed nests than hatched nests. This supports the hypothesis that low food availability causes breeders to forage for longer time periods; 2019 breeding success was among the worst in ~35 years. Our study and results illustrate the importance of a holistic approach to habitat management—gauging habitat quality both in the nesting grounds as well as surrounding foraging grounds. Gathering data to evaluate trends of how nest attendance changes over time and space can become an important tool in determining the fate of a nesting California least tern colony.
Breeding Biology

THE ROLE OF LEARNING IN SEABIRD NAVIGATION

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Seabirds are nature's greatest navigators, efficiently utilising resources many hundreds of kilometres away from their breeding colonies. Recent work has elevated Procellariiform seabirds to one of the main models for animal navigation, and as a consequence much is now known about the sensory requirements for long distance homing in these species. Despite now understanding the cues probably involved in seabird navigation (e.g. olfaction, sun position), little is known about the more cognitive aspects of space-use over the world's oceans. Here, I present the analysis of data from free-ranging and displaced Manx shearwaters (Puffinus puffinus) aimed at understanding the learning and information processing aspects of seabird navigation, and discuss how these findings inform models of the navigational algorithms which underpin animals' space use more broadly.

THE PLIGHT OF BLACK NODDY *ANOUS MINUTUS WORCESTERI* OF THE TUBBATAHA REEFS NATURAL PARK, PHILIPPINES

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The subspecies of Black Noddy (*Anous minutus worcesteri)* is endemic to the Philippines and is known to breed only in the Cagayan Ridge. Tubbataha Reefs Natural Park (TRNP) in the Sulu Sea is the last known intact breeding ground for this subspecies. This study looked into the population development of Black Noddy in TRNP from 2004 to 2019, the threats they face, and the management interventions applied to conserve the species. Data obtained from the regular seabird monitoring was used for this study. From 2004 to 2013, the adult population of the species was increasing, with the highest number of breeders recorded in 2013. The vegetation begun to decline in 2014 due to over fertilization of the trees with bird droppings. However, the decline in the population of Black Noddy begun only in 2017. Black

Noddy nests on trees; thus, the deterioration of vegetation, coupled with habitat competition with the Red-footed Booby (*Sula Sula)*, resulted in the decline of the remaining population of this endemic subspecies. Other threats to the population include marine debris and erosion of the islets. Park management implemented measures to provide breeding habitats for the species. In 2017, temporary structures using bamboo sticks and poles were built to serve as nesting structures. This experiment explored different designs of the structures to ensure maximum nesting turn-out of the Black Noddy. The data show that, in the absence trees, Black Noddy used the temporary structures for their nests, although in much lesser numbers than when the vegetation was intact.

WILL COMMON MURRES BECOME UNCOMMON? REFLECTIONS ON THE ROLE OF SCIENCE IN AN ERA OF CLIMATE CHANGE

Julia K. Parrish

Three decades ago, the Exxon Valdez ran aground killing hundreds of thousands of Common Murres, creating one of the largest environment disasters the Northeast Pacific had experienced, and launching me on a career as a seabird biologist. Thirty years later murres and their Alcid relatives are threatened with starvation and reproductive failure brought on by broad-scale ocean warming, millions of seabirds have died prematurely in a continuing series of mass mortality events, and my seabird natural history and conservation ethic has led me to become a devotee of citizen science and an unabashed champion of the role the public can and should play in natural science. Can an ever more common human population help staunch the loss of seabirds before Common Murres become uncommon?

The Coastal Observation and Seabird Survey Team (COASST) is my way of finding out. COASST is a 20 year-old citizen science program engaging thousands of coastal residents in monthly surveys of beach-cast birds or marine debris. COASST natural science data have been used for a wide range of basic science (e.g., impacts of harmful algal blooms) and actionable science (e.g., fishery bycatch forecasting), as well as the baseline against which hypotheses of historic indigenous hunting and gathering techniques have been assessed. COASST data are also included in a range of tribal, state, and federal annual reporting, both as summarized data and as indicators of system health. COASST social science data have helped to document patterns of participant learning, motivation and identity within hands-on, out-of-doors, adult-focused citizen science.

Together, these studies suggest that:
(1) people are highly motivated to contribute to place-based science; (2) when provided with rigorous training, non-scientists are as good if not better than scientists at data collection; (3) citizen science can provide broad-scale, fine-grain environmental data that is impossible to collect any other way; (4) it's about time we paid attention to these data; and (5) program participants are hungry for knowledge of the state of their coastal ecosystem, and are ready to work to steward and conserve it using the knowledge they have gained.

MARBLED MURRELETS THROUGH TIME: LONG-TERM HOTSPOT PERSISTENCE AND HABITAT USE OF A THREATENED SEABIRD

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In Canada, Marbled Murrelets (*Brachyramphus marmoratus*) are listed as threatened due to their declining population and diminishing habitat. No marine habitat studies have been conducted on this seabird in the northern coastal islands of Haida Gwaii, BC. Since 1997, linear transects have been conducted on the waters of Laskeek bay, collecting information on spatial location and counts of birds along the water. The majority of these surveys have been done in May, June and July, which coincide with the Marbled Murrelets breeding season. We are exploring how these Auklets have been utilizing this body of water throughout the years, by mapping how hotspots have fluctuated temporally and by measuring the weight of importance static environmental variables play in their marine distribution decisions. We hope to find areas of repeated importance to the Murrelets and intend to aid in the understanding of how significant static marine environmental variables play in their habitat needs. These analyses will aid conservation planning for the Murrelet in the Haida Gwaii region and potentially the mainland central coast.

ASSESSING DIET COMPOSITION OF TUFTED PUFFINS (FRATERCULA CIRRHATA) IN WASHINGTON AS A POTENTIAL DRIVER OF POPULATION DECLINE

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Tufted Puffins (*Fratercula cirrhata*) have long been a widespread and relatively common species in the waters of Washington State, with their population in state waters numbering more than 25,000 individuals historically (Hanson and Wiles 2015). More recently, the state population has been estimated to have declined by nearly 90%, to less than 3,000 birds (Hodum et al., unpublished data). Causes of the decline are not well understood, although multiple factors, including changing prey availability and abundance, have been proposed. However, little information exists on Tufted Puffin diet and how diet might be changing in this region. In this study, we initiated a long-term project focused on assessing Tufted Puffin diet in Washington. We used manual photography and trail cameras to assess puffin prey deliveries to nestlings, collecting the following Tufted Puffin diet data for each bill load: prey species, number of prey items, prey item size (estimated length). Through analysis of these data collected over three breeding seasons (2016 through 2018) research found the following: diet consisted of 100% fish, number of fish did not vary between years, and one year recorded smaller fish length. To provide more ecological context, we will be comparing puffin diet with the diet of a sympatric sister species, the Rhinoceros Auklet (*Cerorhinca monocerata*), that forages similarly but has stable/ increasing populations in the region. Gaining a better understanding of Tufted Puffin diet will assist conservation planning for the species by providing insight into the degree to which diet contributes to ongoing population declines.

WINTER DISTRIBUTION AND HABITAT SELECTION OF BRANDT'S CORMORANTS NESTING IN THE COLUMBIA RIVER ESTUARY, OREGON

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Over the past two decades, Brandt's cormorants (*Phalacrocorax penicillatus*) have established a sizeable nesting population around East Sand Island, in the Columbia River estuary (CRE; ca. 1,600 pairs in 2014). This represented a northward shift in their core breeding distribution, which was previously concentrated between Point Conception, California and Cape Blanco, Oregon. The overwinter range of Brandt's cormorants largely overlaps with their breeding extent and stretches from southern tip of the Baja Peninsula to southern Alaska. However, the timing and patterns of post-breeding dispersal are not well understood. Furthermore, it is unclear how this northern breeding population disperses across the species' overall winter range. Here we present preliminary results from the first post-breeding tracking study of Brandt's cormorants captured and tagged in the CRE. In 2019, nine individuals were tracked through the fall migration using solar-powered GPS-GSM tags with integrated temperature-depth sensors. Eight of these individuals travelled north to the Salish Sea and the outer coast of Vancouver Island, and one travelled south to the Central California Coast. We found that once they dispersed, birds often occupied discrete foraging areas, showed repeated use of a roosting location, and performed central place foraging trips. We will compare foraging effort (e.g., daily commuting distance, number of dives / day, and maximum dive depth) between summer and fall. Our results show that individual Brandt's cormorants may select localized foraging areas during the fall and winter months, even without the traditional central place foraging constraints associated with reproduction.

SEABIRD RESTORATION – ADDRESSING INTRODUCED PREDATORS AND RAPIDLY RISING SEA LEVEL

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Rising sea levels are now, and will continue to inundate the islands and atolls of the Papahānaumokuākea Marine National Monument. Fourteen million individuals representing twenty one species make this the largest collection of tropical seabird colonies in the world. Virtually all of the world populations of Laysan (Mōlī, *Phoebastria immutabilis)* and the second largest assemblage of Black-footed (Kaʻupu, *Phoebastria nigripes)* albatross nest here. Efforts are underway to provide new breeding areas for these species and others in the high Hawaiian Islands. At the same time, seabird populations

already on the high islands are under constant threat of predation by introduced predators. Seabird conservation now requires appropriate site selection and predator proof fencing to address both immigrant and local seabird populations. In this presentation we discuss work being undertaken on three of the islands of Maui Nui; Maui, Molokai, and Kahoʻolawe, to provide safe colony locations for resident seabirds and birds that will be displaced by rising sea level and dynamic wave action. All of the planning for each island involves multiple stakeholders. On Kahoʻolawe eradication of rodents and feral cats will obviate the need for fencing but necessitate a multi organization logistics and fund raising effort. Molokai has a dedicated habitat restoration project by Molokai Land Trust and partners where alien weed species are eliminated and native coastal strand vegetation is restored. Social attraction for Mōlī is already in progress. On Maui, modeling for appropriate sites has been performed and initial sites have been selected. We present the context, planning and ongoing work and welcome informed suggestions.

STATUS OF OFFSHORE RENEWABLE ENERGY DEVELOPMENT IN THE U.S. AND BOEM'S AVIAN STUDY STRATEGY TO ASSESS DATA NEEDS AND EFFECTS

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The wind energy industry continues to pursue project development off the coasts of the United States. At the time of the last update on this topic during the third marine spatial planning session at the 43rd annual meeting in 2016, there were nine issued leases for offshore wind energy projects off the coast of the U.S. Since then, the Bureau of Ocean Energy Management (BOEM) has issued additional wind energy leases in the Atlantic, call areas have been identified offshore of California and Hawaii in the Pacific based on industry interest, and the first commercial offshore wind energy facility in the U.S. has been installed and is operational off the coast of Rhode Island. As the lead Federal agency for renewable energy development on the Federal outer continental shelf (OCS), BOEM has initiated a variety of avian studies to provide an improved understanding of offshore ecosystems, a baseline for assessing effects, and the scientific basis for developing regulatory measures to mitigate adverse impacts. BOEM's avian study strategy for the Pacific is proactively addressing key avian issues for environmental assessment of offshore wind projects including available information from recent and historical surveys, updating information where needed due to age of data or identified data gaps, predictively modeling seabird distribution, technology testing for efficient ways to inventory birds on the OCS, assessing vulnerability of marine birds to offshore wind energy infrastructure, and exploring long-term monitoring efforts to track change over time.

A SUMMARY OF ALBATROSS BAND RECOVERY DATA IN THE HAWAII DEEP AND SHALLOW SET LONGLINE FISHERIES

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This project is a summary of Hawaii Longline Fisheries observer program seabird band recovery data that has been accrued during the January 01, 2002 through December 31, 2018 period. The National

Marine Fisheries Service Pacific Island Regional Office Fisheries Observer Program has been deploying observers on board Hawaii-permitted longline fishing vessels, as part of a mandatory requirement, since February of 1994. Seabirds, most commonly the Black-footed and Laysan Albatross species, are know to occasionally interact with the observed longline fisheries. As a part of their regular responsibilities, observers deployed on longline fishing vessels record seabird sightings, document any observed fisheries interactions, assist with handling hooked or entangled seabirds, salvage dead seabirds, and report on compliance with all existing fisheries-related regulations (many of which are aimed at mitigating seabird interactions). Observers also opportunistically record seabird band recovery data. All banding-related data, is maintained in an 'in-house' database, and is also submitted to the United States Geological Survey, Patuxent Bird Banding Laboratory (BBL) where it is joined with existing banding data provided by the United States Fish and Wildlife Service, and others, into a centralized bird banding laboratory database. The results presented here represent a cooperative effort between the NMFS, USFWS, USGS, as well as other governmental and non-governmental agencies.

FOOD AVAILABILITY, CHICK STATUS, AGE, AND ENERGY METABOLITES IN BLACK LEGGED KITTIWAKE CHICKS

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In nest bound chicks, energy mobilization in the first few days of development is vital for fitness-related traits such as growth, begging, and competitive behavior. Plasma metabolites including glucose, triglycerides, and ketones, are key components in the production and use of energy; they may indicate nutritional state and energetic challenges. Food availability and sibling competition are the two main challenges faced by nest bound chicks. A long term food supplementation experiment in free-living Black Legged Kittiwakes (*Rissa tridactyla*) allowed us to test the hypothesis that food availability and hatching hierarchy (first hatched = "A", second hatched = "B") affect glucose, triglycerides, and ketones in five and ten day old kittiwake nestlings. Blood samples and measurements were taken from A and B chicks in nests that were experimentally fed three times a day ("Fed") and from control nests that relied solely on parental foraging at sea ("Unfed"). At five days, unfed chicks had significantly higher glucose and ketone levels, potentially indicative of fasting states, while triglycerides did not differ. Hatching order did not affect five day plasma metabolites. However, at ten days hatching order was significant and B chicks had higher ketone levels while the effects of food availability became weaker. Thus, the relative impact of environmental challenges on energy demands may change over chick development. We plan to examine how food availability, hatching hierarchy and energy metabolites ultimately interact to predict survival.

EFFECTS OF MARINE HEAT WAVES ON GULF OF MAINE SEABIRDS

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Atlantic Puffins (*Fratercula arctica*) and other seabirds nesting in the Gulf of Maine (GOM) are dependent on abundant and accessible forage fish during summer months to feed and fledge young. Warming surface temperatures can cause forage fish to move into deeper water and/or further from shore and reduce their availability to surface-feeding or shallow-diving seabirds. During anomalously warm periods, seabird chicks are fed less often and are sometimes fed lower quality or inappropriately sized food types. This reduced feeding efficiency often results in substantial starvation-induced chick mortality, but the overall effect on fledging success for a colony can vary across seabird species according to their foraging mode and individual chick development strategy. In addition to greater risk of mortality prior to fledging, poorly fed chicks also experience heightened mortality rates following fledging if their body condition is marginal when they leave the nesting island. Over the last two decades, surface temperatures have trended upwards in the GOM but with significant annual and seasonal variability. Intense heatwaves (2012-13, 2016 and 2018) have been associated with poor fledging success and weak year classes, but some recent years with moderate or cool temperatures (2017 and 2019) have been as successful or in a few cases even more successful than historic norms. In this talk we will compare historical fledging and recruitment rates to those during recent warm and variable conditions to consider the possible trajectory of prominent GOM seabird populations.

SEABIRD FORAGING ECOLOGY AS AN INDICATOR OF MARINE PLASTICS DISTRIBUTION ALONG THE CENTRAL OREGON COAST

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With the global issue of marine plastics debris becoming increasingly apparent over the past few decades, research and monitoring projects are invaluable in assessing the extent of plastics contamination in our oceans. Some species of seabirds are known to regularly ingest plastics during foraging and have since been utilized globally as an indicator in marine plastics monitoring. A variety of seabird species commonly wash up on Oregon coast beaches during and immediately following breeding season. These species can be used to assess relationships between plastics accumulation and foraging ecology and serve as an indicator of nearshore and offshore ocean plastics distribution. Gastrointestinal tracts were collected from beached birds along the north-central Oregon coast in 2018 (n=33) and 2019 (n=14) and analyzed for the occurrence of plastics >1mm. A buoyancy analysis test was also developed to determine the vertical distribution of particles in the water column. In 2018, of the 6 seabird species sampled, Common murres (*Uria aalge*), Northern fulmars (*Fulmaris glacialis*), and Sooty shearwaters (Ardenna grisea) were all found to have ingested plastic. Negatively buoyant plastic particles were found in both diving and surface foraging species. When compared to historical seabird necropsy studies these

data showed increasing trends in seabird plastics accumulation in the North Pacific. This study delivers foundational plastics prevalence data for seabirds on the Oregon coast, provides an indicator of plastics distribution throughout the water column alluding to vectors of plastics ingestion, and enhances understanding of the occurrence of marine plastics in different Oregon seabird species.

POST-BREEDING MIGRATION OF KITTLITZ'S MURRELETS FROM THE GULF OF ALASKA TO THE BERING SEA AND BEYOND

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The movements of Kittlitz's Murrelets (*Brachyramphus brevirostris*) during the non-breeding season are poorly known. We captured Kittlitz's Murrelets primarily in glacial-marine habitats adjacent to post-glacial terrestrial breeding habitats in the Gulf of Alaska during May-July 2009-2015. We attached 5-g solar-powered satellite transmitters (PTTs) dorsally with sutures to 47 murrelets. Twenty-seven PTTs provided tracking data after birds departed their breeding areas. Mean tracking duration among those 27 birds was 58.1 d (41.1 SD). All murrelets migrated toward the Bering Sea with short periods of movement (median 2 d, 13 IQR) separated by short stopovers (median 1 d, 14 IQR). During movement periods, travel averaged 79.4 km/d (83.5 SD, 449.1 maximum). All five Kittlitz's Murrelets tagged in May 2011 in Prince William Sound were tracked to the Bering Sea by August and four continued north to the Chukchi and Beaufort seas, accumulating tracks upwards of 2500-4000 km. Most birds appeared to molt along coasts of the Alaska Peninsula or eastern Bering Sea, as evidenced by 2-3 week stopovers during August-October that often ended with PTT failure, which we surmise was caused by a molt-induced detachment of the tag. Using short-term PTT temperature changes as a proxy of diving activity, we found that markedly less diving was recorded at night compared to daylight hours. After PTTs were shed in late-autumn, ship-based visual surveys have indicated that Kittlitz's Murrelets remain in the Bering Sea during winter, where they associate with sea-ice habitats before returning to glacial-marine habitats during the pre-breeding season.

RECENT TRENDS IN MARINE BIRD POPULATION INDICES IN LASKEEK BAY, WESTERN HECATE STRAIT

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Line transect surveys estimating seabird densities in spring and summer have been carried out 4-6 times annually in Laskeek Bay, Haida Gwaii, Canada, since 1997. The surveys used standardized methods

throughout the period during May and June. In addition, the LBCS Camp on East Limestone island has recorded daily seabird observations from on and around East Limestone Island, based on presence/absence since 1990. We examined the effects of weather and sea conditions on apparent densities on transect surveys and combined these two sources of monitoring information to provide estimates of population changes for marine birds in Laskeek Bay since the 1990s. We also assess the effects of large scale oceanographic changes on inter-year variation of detrended data.

COMMON MURRE PRODUCTVIVITY APPEARS STABLE FOR THE SECOND CONSECUTIVE YEAR FOLLOWING SUSTAINED MARINE HEAT WAVE

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From the mid-1900s to 2010, the common murre (*Uria aalge*) breeding population at Yaquina Head Outstanding Natural Area in Newport, Oregon was increasing, with approximately 60,000 nesting murres in some years. Since 2010, reproductive success of murres at the site steadily declined. From 2014-2017, increased predation and unfavorable foraging conditions (e.g. a positive Pacific Decadal Oscillation, PDO, the 'Warm Blob' and El Niño) resulted in near or total breeding failures. In 2018, temperature anomalies were neutral or near neutral and the colony appeared to rebound; we observed increased reproductive success which was sustained into 2019. In 2019 we observed the highest hatching (0.69 ±0.1) and fledging (0.79±0.3) rates at the site since 2010 (similar to or slightly higher than 2018). Bald eagles (*Haliaeetus leucophalus*) continued to be the primary source of depredation and disturbance events, however in 2019 we observed the lowest disturbances rates in the past 10 years (0.15 disturbances/hour). The nearshore plankton community was in flux between cold and warm water dominated copepod species, and murres diets were comprised primarily of smelt (*Osmeridae spp*) with other species present. For the seventh consecutive year, murres abandoned nesting on sub colony Flat Top Rock, while new nests appeared in surrounding areas. This may suggest more flexible nest site fidelity than typically observed with murres. Temperature anomalies detected near Newport post breeding season could indicate the onset of a second Marine Heat Wave. If conditions persist, this could fare poorly for the Yaquina Head murres in future breeding seasons.

LONG-TERM SPATIOTEMPORAL TRENDS AND DISTRIBUTION OF BRANDT'S CORMORANT NESTING ON THE OREGON COAST (1988-2014)

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Brandt's cormorants (*Phalacrocorax penicillatus*) are considered a relatively sensitive indicator of changing ocean conditions, however our knowledge of population trends in Oregon has been limited. We quantified spatiotemporal population changes in Brandt's cormorants in four years over a 26 year time-span (1988-2014) at all known coastal breeding sites in Oregon from Seaside, Oregon to the California border using a long term data set of historical aerial photos. There was a 21% coast wide decline in Brandt's cormorant nests from 1988 to 2014. The distribution of nests over all coastal regions (north, central, and south) remained relatively stable from 1988-2003, but from 2003-2014, nests in northern third of Oregon decreased by 46%, while the number of nests elsewhere increased. The number of active Brandt's cormorant colonies followed a similar trend, remaining stable along the whole coast from 1988-2003 followed by declines in the northern coast of Oregon and growth elsewhere during 2003-2014. Oceanographic conditions from 1988 – 2014 were highly variable, but preliminary analysis suggests that the population and distribution of Brandt's cormorants may be associated with changes in indirect indices of foraging conditions. Additionally, increased bald eagle populations (*Haliaeetus leucocephalus*) were documented in highest regional densities on the north coast with nesting effects on other seabird species (e.g. common murres (*Uria aalge*) and possible effects on Brandt's cormorants. Since 2014, the Oregon coast has experienced sustained temperature anomalies and further incorporation of these data may provide insights into the response of nesting Brandt's cormorants to more extreme conditions over a large spatiotemporal scale.

HOLDING BACK THE HORDES - HOW EFFECTIVE IS PREDATOR CONTROL IN PROTECTING ENDANGERED SEABIRDS IN UPPER LIMAHULI, KAUA'I

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On the island of Kaua'i, two endangered seabirds (Newell's Shearwater *Puffinus newelli* and Hawaiian Petrel *Pterodroma sandwichensis*) are at risk from a wide range of introduced predators including cats,

rats, pigs and Barn Owls. Predator control is thus a key element of seabird management. As a case study we consider the effectiveness of predator control at the Upper Limahuli Preserve, a protected area in the north-west of Kaua'i. As well as an ungulate proof fence, the site has had a combined predator control and seabird monitoring project in place since 2011. Using multiple techniques, including burrow monitoring, acoustic monitoring and burrow cameras, we consider this nine year data set to assess how predator control operations have affected endangered seabirds breeding in the area. We also present the results of a population simulation model to consider population trajectories at Upper Limahuli under two scenarios; with and without predator control. The results clearly indicate a direct benefit to endangered seabird populations within the Preserve. Reproductive success rates and call rates for both species have increased over time, while depredation rates have declined for Black Rats in particular. However, some introduced predators have been harder to tackle than others. Cats continue to appear on site annually and can kill multiple breeding birds in a short period of time. Barn Owls are even harder to deal with, requiring specialized techniques. We discuss the importance of future management actions at the site, including the addition of a predator proof fence and enhanced and long term predator control operations.

GASTROLITHS AMONG ADÉLIE PENGUIN (*PYGOSCELIS ADELIAE)* CHICKS: MINERALS AND MICROBIOTA ACQUISITION AS AN ALTERNATIVE EXPLANATION

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Gastroliths have been observed in different species, however, explanations about the nature of stone ingesting behavior remains unclear. Aiding in digestion, buoyancy control, and avoidance of stomach collapse during starvation have been suggested. We quantified characteristics of >300 stones from Adélie penguin (*Pygoscelis adeliae*) chicks' stomachs and their nests at Cape Crozier colony, Ross Island, Antarctica. We weighed stones and virtually reconstructed their volumes and surface area from >5,000 pictures using software Agisoft Metashape and CloudCompare software. We found no correlation between stone weight and stomach contents of chicks from their nests. However, stones in chick

stomachs were on average smaller and flatter than stones from their nests. Interestingly, 3-4 day old penguin chicks already had stones in their stomachs and we observed chicks vomiting stones at the end of the season. Overall, our study does not support previous hypothesis regarding stone ingestion as a form of buoyancy control or in response to starvation in penguin chicks. We proposed ingestion behavior may fulfill a need for minerals or microbiota. Stone ingestion might provide nutrients unattained from penguin chick's primary diet or introduce microbiota into their systems. Microbiota can coevolve with its host, offering a profound influence on the host's immunological process. We propose future research to evaluate differences in stones composition and microbiota among nests in future studies and to consider the possible impact of those differences on individual success, quality, and survival.

CORMORANTS, CURRENTS, AND CAPES: FORAGING SEABIRDS INDICATE JUVENILE FISH ABUNDANCE PATTERNS IN MARINE PROTECTED AREAS

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Effective adaptive management of marine protected areas (MPAs) requires that managers establish realistic expectations for how quickly fish populations will respond to protections. Setting realistic timelines for population change within individual MPAs requires an understanding of how many juvenile fish enter that populations each year. Estimates of juvenile fish abundance can be time consuming and difficult. We are therefore developing a cost-effective index using seabird foraging to measure spatiotemporal variability in annual juvenile fish abundance. We used the foraging rates of Brandt's cormorants (Phalacrocorax penicillatus) and pelagic cormorants (P. pelagicus) to index juvenile fish abundance at 46 sites throughout California's MPA network. We created models relating seabird foraging rates to coastal geography and annual upwelling, two important determinants of fish larval abundance in nearshore habitats. Our seabird index successfully showed that the effects of upwelling variability on local juvenile fish abundance differed depending on coastal geography. In the lees of headlands, seabird foraging rates were higher and more stable with respect to upwelling variability. For all other coastal configurations, pulsed upwelling was associated with foraging rates. These patterns in seabird foraging are similar to patterns of fish larvae abundance around coastal headlands reported in other studies. Thus, seabird foraging shows great potential as a tool to monitor spatiotemporal variability in nearshore juvenile fish abundance.

NON-BREEDING DISTRIBUTION OF ANCIENT MURRELETS BREEDING AT AIKTAK ISLAND, EASTERN ALEUTIANS, ALASKA

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Non-breeding distributions remain unknown for most seabird species that breed on the Alaska Maritime National Wildlife Refuge. As a result, the links between distributions, overwinter ecology, and population-level processes are poorly understood despite their importance for refuge management and

conservation. In 2018 we deployed 24 geolocation loggers on breeding adult ancient murrelets (*Synthliboramphus antiquus*) on Aiktak Island, in the eastern Aleutians, to increase our understanding of this species migratory behavior and habitat use throughout the annual cycle. We recovered 19 loggers in 2019. Analysis of light level data showed birds left the breeding colony and remained in the eastern Aleutians in June; between July and September the majority (79%) of birds remained in the eastern Aleutians or moved north into the eastern and northern Bering Sea. In late July, four birds (21%) rapidly migrated along a northern Bering Sea route west to the Kamchatka Peninsula coast and remained until mid-September. Migration to wintering areas on the Asian side of the Pacific began in late October and continued into November. All birds spent the middle of winter in the Sea of Japan and/or the Yellow Sea. Eastward spring migration was initiated from mid-March to late April, with all birds located in the eastern Aleutians by May, prior to initiating breeding at Aiktak Island in late May. These distribution and migratory route results will be compared to those found by Gaston for ancient murrelets from British Columbian colonies.

CONFIRMATION OF BREEDING OF THE RED-LEGGED KITTIWAKE *RISSA BREVIROSTRIS* AT ST. MATTHEW ISLAND, ALASKA

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The red-legged kittiwake is the only seabird endemic to the Bering Sea and a species of conservation concern due to a relatively small population with few breeding locations. The species has a very restricted breeding distribution, limited primarily to four major locations (the Pribilof Islands, Bogoslof Island, Buldir Island, and the Commander Islands). During June and July, 2018 we observed c. 200 red-legged kittiwakes occupying cliff habitat and exhibiting breeding behavior on St. Matthew Island, Alaska; however, we were unable to confirm breeding at that time. Based on these observations, we returned to St. Matthew Island in July, 2019 to confirm breeding by red-legged kittiwakes and to obtain an estimate of their breeding population. We surveyed the entire coastline of St. Matthew, Hall, and Pinnacle islands, concentrating our efforts on kittiwake nesting habitat. We counted 261 red-legged kittiwakes attending the cliffs, all of which were observed clustered in two primary locations along the northwest coastline of St. Matthew Island. Approximately 65% of the birds we observed were associated with a nest, and approximately 75% of the observed nests appeared to be active. A majority of the active nests contained visible chicks, confirming breeding for the first time at this location.

EVIDENCE FOR THE COEVOLUTION OF DIFFERENTIAL MIGRATION IN SHOREBIRDS (SCOLOPACIDAE) AND PEREGRINE FALCONS (*FALCO PEREGRINUS*)

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Many migratory shorebird and seabird species exhibit differential migration, which is defined as sex- and/or age-based differences in migratory movements. Numerous hypotheses attempt to explain this phenomenon, which are primarily focused on either external (i.e. related to migration distance, morphology, or physiology) or internal (i.e. conditional responses) factors. However, few hypotheses have been tested with empirical evidence from shorebirds, which may be inconsistent or differ by species. Peregrine Falcons (*Falco peregrinus*) also exhibit differential migration, and shorebirds may comprise a substantial portion of their prey, particularly on migration and at wintering sites. The timing and routes of shorebird migration may have coevolved in response to that of peregrine falcons. Here, we review the current state of evidence for the coevolution of differential migration of shorebirds and seabirds with that of Peregrine Falcons. The relationship may be dynamic, with both shorebirds and peregrines altering their migration timing or pathways. For example, sandpipers (*Calidris mauri*, *C. alpina pacifica*) in British Columbia have altered their migration timing and routes to avoid Peregrine Falcons. Western sandpipers (*C. mauri*) have shortened the duration of time spent at stopover sites as Peregrine Falcon have populations increased in recent years. Conversely, female peregrines may time their migration to coincide with the larger waterfowl that they hunt more efficiently than male peregrines. Considering these and other findings from the scientific literature, we examine evidence for coevolution in differential migration strategies employed by shorebirds and peregrine falcons and suggest priorities for future research.

GEOGRAPHIC STRUCTURING OF ANTARCTIC PENGUIN POPULATIONS

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We hypothesize that regional spatial organization of Adélie, emperor, chinstrap and Gentoo penguin breeding populations is affected by proximity and size of adjacent colonies, availability of breeding habitat, and proximity of polynyas and submarine canyons. The hypothesis of Furness & Burkhead (1984), regarding geographic structuring of seabird populations by forage competition, was tested previously for Antarctic penguins before the availability of extensive biologging to quantify colony foraging areas and when assessments of colony size were a compendium of historical counts. Results were problematic. These critical data sets, updated, are now available following 20 years of biologging and real-time satellite assessment of colony locations and sizes. We collated colony counts from these recent sources, as well as the literature on foraging ranges, to determine the relative importance of the four factors listed above and conclude that inter- and intraspecific trophic competition importantly affects geographic structure, though not necessarily in the same way depending on species. The equal spacing of emperor penguin colonies is remarkably constant, seemingly as a function of foraging range (i.e. repulsion among neighboring colonies). In contrast, colonies among the other penguin species are clustered, with small colonies existing adjacent to one another, within a zone characteristic of the outer edge of the foraging area of large colonies. Colonies and especially clusters occur proximal to polynyas and canyons. Results are relevant to assessing effects of climate and other factors on penguin population trends, as we suggest it is necessary to consider patterns at the regional or cluster scales for a valid view of change.

DEMOGRAPHY OF THE YELLOW-FOOTED GULL (LARUS LIVENS) NESTING IN THE ESPIRITU SANTO ARCHIPELAGO AND LA PAZ BAY, B.C.S., MEXICO

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The Yellow-footed Gull (YFGU), Larus livens, is an endemic Mexican seabird breeding exclusively on islands of the Gulf of California. It is subject to "special protection" under Mexican law NOM-059. Every year the YFGU breeds in the Espiritu Santo Archipelago (ESA) complex, in La Paz Bay (LPB) in the southern part of the gulf. Despite its endemism, in the last ecological assessment of natural protected areas of the northwest, the National Commission of Natural Protected Areas has declared that there is not enough information to establish the current status and population trend of this species. In order to determine colony sizes, nest size and reproductive success of YFGU, in 2019, between March and June, visits were made biweekly to the islands: Ballena (BALI), Gallo (GLOI), Gallina (GNAI) and to Bonanza Beach (BZAB) within the ESA and every three days to Gaviota Island (GTAI). The largest colony was GTAI with 74 active nests, followed by BALI and BZAB with 29 and 19 nests respectively. The smallest colonies were those established in GNAI with 6 nests, while GLOI had 16 active nests. No significant differences were observed on the nesting size, which presented a modal average of 3 eggs in the five sites where the sampling was carried out ($Xi2 = 5.14$, $df = 4$, $p = 0.27$). Regarding reproductive success, GNAI had the highest survival of chicks with 79% ($n = 14$), while in IGTA 41% ($n = 198$) survived of hatched eggs. The studied colonies show effects of density dependence, so deeper analyses will be carried out to corroborate this hypothesis. This work represents an effort to update studies of the YFGU after 30 years from the last studies conducted in La Paz Bay and Espiritu Santo Archipelago.

INDIVIDUAL PLASTICITY IN FORAGING BEHAVIOR IN BLACK-LEGGED KITTIWAKES (RISSA TRIDACTYLA)

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Black-legged kittiwakes (*Rissa tridactyla*) on Middleton Island, Alaska exhibit seasonal and annual variation in foraging behavior. However, the extent of individual variation within and among years is still relatively unexplored. Understanding individual plasticity can be critical for our understanding of how much individuals are able to alter behavior in the face of environmental changes. For this study, we looked at a variety of foraging trip characteristics for 10 individuals (five males, and five females) from the years 2017 and 2018 and investigated variability within individuals and between years. GPS units were placed on these birds during chick rearing for both years and the devices remained on for 3-4 days. The data showed that some individuals were much more consistent in the foraging locations between years than others and there was no clear difference between males and females. There was a significant

correlation between number of trips taken in 2017 and 2018 for each individual. However, there were no correlations between years for maximum trip distance, total trip length, or proportion of time on trip. These differences between years were driven more by some individuals than others. This suggests that some individuals are more plastic in their behavior than others. This is a preliminary analysis for a future study on how differences in individual plasticity in foraging behavior affect reproductive success.

IMPACT OF THE 2014-2016 MARINE HEAT WAVE ON SEABIRD POPULATIONS IN COOK INLET, ALASKA

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An extreme marine heat wave in the northeast Pacific Ocean during 2014-2016 precipitated the largest recorded die-off of Common Murres (*Uria aalge*) in the North Pacific in 2015-2016. The apparent cause of mortality was starvation, coincident with a large-scale decrease in forage fish availability and quality. To detect population level effects following the die-off, we censused whole colony populations and estimated productivity (# chicks fledged/eggs laid) of murres and Black-legged Kittiwakes (*Rissa tridactyla*) at breeding colonies (Chisik and Gull islands) in Cook Inlet, Alaska during summers 2016-2019 and compared our findings with earlier (1995-1999) studies. Recent census counts for murres at Gull declined steadily from a high of 7636 in 2016, which was slightly lower than historic levels (mean 8937 SD 1852), to the lowest count (3147) in 2018; they increased slightly (3755) in 2019. At Chisik, counts for both species were below historic estimates in all years. For the first time on record, murres at both colonies failed to fledge chicks in 2016, 2017, and 2018. In 2019, murres at Chisik also failed, but low numbers of murres fledged from Gull. In contrast, kittiwake counts at Gull across recent years (mean 6392 SD 834) were similar to historic levels (mean 6988 SD 1179). Kittiwake productivity was at or near zero at Chisik in all years and at Gull in 2016 and 2018. In 2017 and 2019, however, kittiwakes at Gull had above average productivity. We observed population-level effects on seabirds following the heat wave, suggesting a chronic scarcity of quality forage; however, populations are starting to show signs of recovery. Demographic effects were more pronounced in murres than in kittiwakes in Cook Inlet.

METHODS FOR LEACH'S STORM-PETREL POPULATION ASSESSMENT: A CASE STUDY FROM MAINE, USA

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Nocturnal burrowing seabirds are notoriously difficult to count, and therefore not consistently surveyed. Leach's Storm-petrels (Oceanodroma leucorhoa) in Atlantic Canada were found to have experienced significant declines in the past 20 years, which led to a survey of neighboring Maine colonies. Previously

assessed in the 1990's, we censused major Maine colonies again in 2018-2019 and found stable or increasing populations at 5 major colonies (greater than 100 pairs). On the largest colony islands (Great Duck Island and Little Duck Island) a transect and plot method to count burrow density, stratified by habitat type was used. A sample of burrows in each of the open, forest edge, and forest interior habitats was checked by manual grubbing and/or burrow scope to determine the occupancy rate. Transects and plots were also used on the small, treeless Old Man Island. This island's habitat was less variable than a forested island, but had pockets of high density nesting on more steep and shaded slopes. Plot densities for low and high density were applied to the estimated areas of each habitat. Complete counts of burrows were done on the small, treeless islands of Matinicus Rock and Eastern Egg Rock, with plots to assess occupancy. The unique qualities of different nesting sites require slightly different methods to assess population numbers.

THE CHALLENGES OF MANAGING CONSERVATION-RELIANT SEABIRDS

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Many imperiled seabird species are conservation reliant: they face threats that can't be eliminated but only managed, and the management may need to continue for a very long time. As climate change pushes more species toward extinction, the queue of conservation-reliant species will grow. Resources for conserving imperiled species are already inadequate. The long-term demands of conservation-reliant species will further strain conservation resources and societal support. Not all needs can be met, so conservation efforts must be prioritized. Seabirds are wide-ranging and face very different threats on their breeding grounds than they do while at sea, so their conservation and management are particularly challenging. We discuss successes, failures, and lessons learned from conservation efforts for Hawaiian petrels, Newell's shearwaters, and other conservation-reliant seabirds, emphasizing the legal, social, cultural, economic, management, and science challenges they face. We conclude with a discussion of ways forward.

TESTING THE ATTRACTION OF TWO PROCELLARIIIFORM SEABIRDS TO DIMETHYL SULFIDE

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The organosulfur Dimethyl sulfide (DMS) is produced during phytoplankton grazing and, although its emissions are higher in the Antarctic and sub-Antarctic oceans, it occurs in oceans worldwide. Many Procellariiform seabirds, known for their high olfactory capacity, use this info-chemical to locate productive feeding areas. Moreover, DMS responsiveness has been suggested to be related to frequency of plastic ingestion in seabirds, a problem that severely affects many Procellariiforms. Considering that, and that most DMS response tests were conducted in sub-Antarctic species, this study aimed to experimentally test the response of two Procellariiform species that breed in the Northern Hemisphere. Using the Y-maze, we tested the DMS response of Leach's storm-petrel (*Oceanodroma leucorhoa*), a well known responder to DMS with significant reports of plastic ingestion, and of Streaked shearwater (*Calonectris leucomelas*), that presents low incidence of plastic ingestion and with undetermined DMS response. As expected, a significant percentage of storm-petrels chose the DMS odor in the maze (50%), confirming the species attraction to this info-chemical. However, only 10% of the tested shearwaters chose the DMS, with the remaining 90% of birds not making a choice at all in the maze. These results suggest that, in controlled environment, Streaked shearwaters do not respond to DMS at concentrations similar to those found at sea, in opposition to the responsiveness demonstrated by other shearwaters under similar conditions. They also suggest that burrow-nesting habits might not be a proxy for DMS response. Finally, these findings will contribute to a better understanding of the correlation between DMS responsiveness and plastic ingestion frequency in seabirds.

BLACK-LEGGED KITTIWAKE CHICKS SHOW NO SIGNIFICANT BEHAVIORAL RESPONSE TO DIMETHYL SULFIDE: AN EXPERIMENTAL STUDY

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Dimethyl sulfide (DMS), an organosulfur compound distributed in oceans worldwide, has been shown to associate with high primary productivity areas. This naturally occurring odor has been proven to be an attractant for many Procellariiforms seabirds, as they use an olfactory navigational cue to locate foraging grounds. Recent studies have indicated a relationship between DMS responsiveness and frequency of plastic ingestion, suggesting that seabirds may be unable to identify between plastic debris and prey. Considering that plastic ingestion is a threat that extends to other groups of seabirds, DMS response studies should be conducted in non-procellariiforms seabirds as well. Here, we test the DMS response of Black-legged kittiwakes (*Rissa tridactyla*), a Charadriiform with high olfactory capacity, examining a potential sensory mechanism of plastic ingestion during foraging. We focus on kittiwake chicks, from different ages, (10-33 days old) and whose parents are free-raging and naturally breeding, that were presented with three different odors on their nest: distilled water, capelin (*Mallotus villosus*)

and DMS. We recorded the subsequent behavioral response of 60 chicks; in particular, the frequency of pecking at the odor spot within a nest. Ninety percent of those tested for capelin odor responded positively, meaning that they pecked repeatedly at the odor spot, and only 5% of those tested for DMS showed a positive response to the odor. The results reinforce that kittiwakes possess high olfactory capacity, and they indicate that kittiwakes might not use DMS as an olfactory foraging cue. Moreover, these findings suggest the need for further studies about the correlation between high olfactory capacity and plastic ingestion frequency.

POPULATION-LEVEL PLASTICITY IN FORAGING BEHAVIOR OF WESTERN GULLS (*LARUS OCCIDENTALIS*)

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Plasticity in foraging behavior among individuals, or across populations may reduce competition. Western gulls (*Larus occidentalis*) consume a range of marine and terrestrial foods but foraging patterns are not well understood. We used GPS loggers to compare foraging behavior of western gulls breeding at Southeast Farallon Island (SFI; n = 41 gulls) where they conducted more oceanic trips (n = 90) of shorter duration (3.8 $\pm$ 3.3 SD hours) and distance (27.1 $\pm$ 20.3 km) than trips to the mainland (n = 41) that were 4 times longer and 2 times farther away. Conversely, gulls from Año Nuevo Island (ANI; n = 20 gulls) foraged on land more frequently (n = 103) but trip durations (3.6 $\pm$ 2.4 hrs) and distances (20.8 $\pm$ 9.4 km) did not differ significantly from oceanic trips (n = 42). Foraging at sea was more random compared to trips over land where gulls from both colonies visited the same sites on multiple trips. The total home range of gulls from SFI (14,230 km^2) was 4.5 times larger than that of gulls from ANI, consistent with greater resource competition resulting from a larger abundance of seabirds at SFI. Population-level plasticity in foraging behavior was evident and dependent on habitat type. In addition, gulls from SFI were away foraging longer than gulls from ANI (22% vs. 7.5%, respectively), which impacts the defense of territories and attempts at nest predation by conspecifics. Our results can be used to explain lower chick productivity at SFI, and can provide insight into increased gull activity in urban areas.

MARINE SPATIAL PLANNING: GLOBAL TRENDS AND PRIORITIES

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For more than a decade, marine spatial planning has been used as an approach by governments and communities to plan for existing and future marine activities, and to improve management of the oceans. Common objectives, or reasons, to develop marine plans vary but typically include increasing marine protection or protected areas for ecologically significant or culturally important species and

habitats, improving sustainability of marine activities, siting economic development, and most recently to plan for climate change. Seabirds and other wide-ranging pelagic species present a particular challenge for marine spatial planning because most plans are developed at national or sub-national scales and many pelagic species travel thousands of kilometers and cross multiple jurisdictions. With increasing concerns about the effects of climate change on pelagic species, and how changes in oceanographic conditions will affect distributions and abundance of these species, the need to coordinate information at regional or basin-wide scales becomes more important. Additionally, the integration of offshore plans with the coastal zone is essential in order to plan for species, like seabirds, that span terrestrial and marine environments. In this presentation, I will provide a summary of global trends in marine spatial planning, discuss drivers relevant to seabird conservation in relation to marine protected areas, climate change and marine uses, and provide suggestions for priorities in research topics for seabirds to best inform marine spatial plans with examples from Pacific, Atlantic and Western Indian Oceans. In closing, I will introduce the 5th Marine Spatial Planning session for the Pacific Seabird Group 47th Annual Meeting.

LANDFILLS REPRESENT SIGNIFICANT ATMOSPHERIC SOURCES OF EXPOSURE TO HALOGENATED FLAME RETARDANTS FOR URBAN-ADAPTED GULLS

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A suite of halogenated flame retardants (HFRs) including polybrominated diphenyl ethers (PBDEs) and emerging HFRs have been determined in tissues of ring-billed gulls (*Larus delawarensis*) nesting in the Montreal area (Quebec, Canada). More specifically, elevated concentrations of the highly hydrophobic DecaBDE were reported in ring-billed gull plasma, and spatial tracking showed that these concentrations in males were correlated with the time spent in landfills. Gulls feeding in and around landfills may be exposed to HFRs via dust and particle ingestion and inhalation, which prompted us to design a miniature passive air sampler that can be carried by gulls and collect gas- and particle-phase HFRs. The overall objective of this study was to investigate the atmospheric exposure of urban-breeding ring-billed gulls to PBDEs and selected emerging HFRs. We equipped 67 nesting gulls with a miniature passive air sampler and a GPS datalogger in order to collect HFRs in air while monitoring their movements outside the colony during two weeks. HFRs were extracted from the sorbents of the samplers (polyurethane foam and glass fiber). The major PBDE congeners determined in the samplers were characteristic components of the commercial mixtures PentaBDE and DecaBDE. Also, a few emerging HFRs were detected, although at lower levels. The daily sampling rates of PBDE mixtures were positively correlated with the presence probability of gulls in landfills, but not the emerging HFRs, which suggests alternative sources for these chemicals. This study showed that landfills represent major environmental sources of atmospheric exposure to PBDEs for birds that use these sites to forage on predictable energy-rich human food resources.

A GLOBAL DATABASE OF ACTIVE SEABIRD RESTORATION PROJECTS

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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 techniques, such as using social attraction and translocation can be applied to further recover seabird populations, particularly where removal of key threatening processes like invasive species is not enough for the long-term conservation of a species. However, there is a lack of common knowledge of how to select and apply active restoration methods with the greatest chances of success. Building on a previous review by Jones and Kress (2012), we've created the Seabird Restoration Database, a data center of active seabird restoration methods and outcomes, to assist in knowledge transfer among practitioners seeking to use restoration tools to recover seabird populations. The database structure was developed in 2019, and data collection began in January 2020. The collection process involves literature reviews and expert surveys, aiming to gather unpublished technical documents as well as first-hand knowledge of events and outcomes. The research will result in a dataset of active seabird restoration projects from around the world – where they are happening, the species targeted, the methods applied, and the restoration outcomes. The database will be made available online in 2021 and will serve as a foundation from which other applied questions about seabird restoration, and wildlife reintroductions in general, can be formed to help enhance the activity and its outcomes.

ESTABLISHING A NEW BREEDING POPULATION OF NEWELL'S SHEARWATERS ON MAUI

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The Newell's shearwater (*Puffinus newelli*) population has dramatically decreased in size and distribution in Hawaii, and the species is listed as threatened under the US Endangered Species Act (ESA) and critically endangered by the IUCN. Management, until recently, has been solely directed at caring for the remaining populations in the northwestern portion of Kauai. On West Maui, where the species is all but extirpated, a conservation initiative was undertaken as mitigation for potential wind energy-collision mortality under a Habitat Conservation Plan required by the ESA. Two ~1.8 hectare fenced management areas were constructed, and pigs, rats, mongoose, and feral cats were excluded. In addition, nest boxes were installed (50 each exclosure), vegetation was managed, and social attraction media (call playbacks and decoys) were instituted. Nest site visitation and activities are monitored using covert IR game cameras to document behaviors, visitation rates, breeding status, and reproductive

performance. Visitation by seabirds started in the third year of social attraction, the first eggs were laid but did not hatch in years 4 and 5, and the first fledglings (n=5) were produced in year 6 (2019), from 20 occupied nests. Efforts were modified in several ways in 2019, and likely contributed to success. We examine the steady annual increase in nest site visitation and breeding success in the context of population modeling and discuss factors affecting the efficacy of social attraction toward establishing new nesting colonies of this species.

TESTING THE USE OF ARTIFICIAL SOCIAL ATTRACTION ON TWO SPECIES OF SEABIRDS; PIGEON GUILLEMOTS AND PARAKEET AUKLETS

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For some species of seabirds, individuals are unlikely to nest without the presence of conspecifics to provide information on local breeding conditions. Artificial social attraction has proven a valuable tool in the restoration of seabird populations by bridging this "information barrier". In this study, we test the effectiveness of artificial social attraction to encourage nesting by two seabird species, parakeet auklets (*Aethia psittacula*) and pigeon guillemots (*Cepphus columba*). We deployed social attraction arrays on the Naked Island Group in Prince William Sound, Alaska where an introduced predator, American mink (*Neovison vison*), was recently eradicated. The arrays were set up in unoccupied historical nesting habitat from May through August of 2016 to 2018, with control sites nearby. Arrays consisted of audio playback of seabird calls as well as decoys and mirror boxes to simulate active colonies. We found that pigeon guillemot attendance was significantly higher at sites with social attraction arrays than control sites without arrays, though we did not observe guillemot nesting attempts at any of the control or experimental sites. We did, however, observe at least one nesting attempt made by parakeet auklets at a social attraction array during the final year of this study. This was the first nesting attempt documented at the Naked Island Group by parakeet auklets since 2007. These results provide evidence that social attraction can be an effective tool for encouraging the use and recolonization of historical nesting habitat for both pigeon guillemots and parakeet auklets.

GLOBAL SEABIRD BYCATCH ASSESSMENT IN TUNA LONGLINE FISHERIES WITH FOCUS ON THE SOUTHERN HEMISPHERE

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Longline fisheries have been identified as a major threat to seabirds, especially albatrosses and petrels. However, a rigorous and data-driven assessment of seabird bycatch at a global scale had never been

undertaken. We collaborated with scientists from ten fishing nations and representatives of tuna Regional Fisheries Management Organizations (tRFMOs) to estimate global seabird bycatch in pelagic tuna longline fisheries in the Southern Hemisphere. Three basic approaches were used as standard estimation procedures for analysis: two bycatch per unit effort (BPUE) standardization and one risk assessment. Observer data by 5x5 degree and by quarter from nine sources were combined for a joint analysis, representing the largest and most comprehensive seabird dataset ever compiled. Estimates of seabird density distribution based on tracking data and total longline effort available from the tRFMOs were also included in the analyses. Two best models selected for each approach and a Stratified Ratio Based Estimate produced broadly similar estimates of total seabird mortality, with a mean of 36,000 birds killed south of 20° S in 2016, which is considered an underestimate as cryptic mortality was not accounted for. Selected models in all approaches incorporated seabird density distribution data, and all approaches largely reduced the uncertainty observed when raising the BPUEs alone. The value of this global collaborative approach warrants repeated assessment to evaluate temporal changes in bycatch impact and could be applied to the Northern Hemisphere to undertake an even more comprehensive global assessment including both hemispheres.

PUTTING SEABIRD BYCATCH IN GILLNET FISHERIES ON THE MAP IN JAPAN

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Bycatch in gillnet fisheries has been identified as a major driver of population declines in some seabird species, with a global estimate of 400,000 birds killed annually through entanglement in gillnets. In Japan, seabird bycatch data in gillnet fisheries is limited, yet gillnets are extensively used in coastal areas and bycatch is thought to occur to a considerable extent in these fisheries. In order to identify priority ports from which to conduct detailed data collection and mitigation testing, we developed a nation-wide map identifying potential hotspots for gillnet bycatch. This was achieved by mapping three geographical layers; 1) breeding colonies of 19 seabird species considered susceptible to gillnet bycatch and their foraging ranges, 2) areas permitted for gillnet fisheries and volume of fish landings from gillnets, and 3) areas with water depth <100 m (a factor identified as important by fishers). Bycatch hotspots were particularly concentrated in eastern and northwestern Hokkaido, and the northeastern region of the main island, Honshu. We have been engaging with a fishing community in northwestern Hokkaido for at-sea trials of potential mitigation measures, where we expect further collaboration in the future. Initial communication with a few other fishing communities indicates some resistance to “outsiders”, and

further engagement with them likely depends on identification of effective mitigation measures elsewhere. Clear contrast in responses by those communities suggests a strategic and tailored approach to each community is key to successful engagement.

STRATEGIES TO REDUCE CONFLICTS BETWEEN BONIN PETREL (PTERODROMA HYPOLEUCA) AND REFUGE MANAGEMENT ACTIVITIES AT MIDWAY ATOLL

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Bonin petrels (*Pterodroma hypoleuca*) are small burrow-nesting seabirds that breed in high densities at Midway Atoll National Wildlife Refuge in Papahānaumokuākea Marine National Monument. However, they have not always been plentiful. The breeding population was estimated to be 5,000 breeding pairs in 1979 and had increased to 32066 in 1994 following years of rodenticide application around human inhabited structures on the Naval Air Facility. After eradication of rats from Midway in 1996, Bonin petrel population swelled to 129773 pairs by 2008. Additional conservation measures such as restricting lights and night-time motor vehicle use, and removing above-ground utility lines have also enhanced survival. This increase in Bonin petrel population (likely one of the only *Pterodroma* species to live in the midst of a small town) has resulted in increased human-wildlife conflicts as Refuge staff implement necessary management activities such as construction, demolition, tree removal, and preservation of historic resources. Refuge staff minimize impacts to Bonin petrels with a variety of strategies such as concentrating disruptive work during the time when breeding populations are lowest. As the Bonin population continues to grow, however, this time window has contracted because birds stay in the colony later, and return earlier, making management increasingly challenging. Refuge staff employ tactics to minimize impacts such as laying geotextile fabric to exclude petrel burrowing, and temporarily removing nestlings from areas being disturbed. We anticipate that the upcoming mouse eradication will further benefit Bonin petrels but this will then require increased ingenuity in developing solutions to reduce conflicts.

BREEDING PRODUCTIVITY OF NORTHERN HEMISPHERE SEABIRDS: VARIABILITY BETWEEN LARGE MARINE ECOSYSTEMS (LME)

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As the world warms, extreme climate events such as marine heatwaves (MHW) are becoming more frequent and intense, but the consequences of these events on different large marine ecosystems (LME) are not well known. Seabird breeding productivity (i.e., breeding success female$^{-1\text{-}yr}$) is a well-understood, available indicator suitable for assessing similarities and differences in change across marine ecosystems. In this study, we tested the hypothesis that seabird breeding productivity tracks regional variability in climate change. To test this hypothesis, we conducted a meta-analysis of ~70

time-series of seabird productivity representing about 2,200 annual data points from the northern hemisphere. Using GLMM, we investigated if seabird breeding productivity was related to regional variability in the rate of ocean warming, velocity of climate change (shifts in isotherm geography), or frequency and intensity of MHW. There were no clear ecosystem-scale trends in breeding productivity for planktivorous species, but the probability of breeding failure for omnivorous/piscivorous species increased in many LME, except in the California Current ecosystem where failure due to ENSO has been a regularly-reoccurring event through time. Non-ENSO related MHW and corresponding changes to epipelagic food webs appear to be mechanistically related to the increasing frequency of seabird breeding failure in various northern hemisphere LME, particularly after the year 2000.

THE USE OF PASSIVE ACOUSTIC RECORDERS TO MONITOR THE OCCUPANCY AND RELATIVE ABUNDANCE OF ALEUTIAN TERN COLONIES ACROSS ALASKA

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The Aleutian tern (*Onychoprion aleuticus*) is a vulnerable seabird that nests only in Alaska and the Russian Far East. The relatively small population size, low nesting densities and ephemeral attendance at colonies have made it difficult to determine the reasons for this species' population decline. The remoteness of most Aleutian tern colonies makes it unfeasible to survey many colonies multiple times over the nesting season. We conducted acoustic surveys at 17 colonies across Alaska during the 2018 season to determine if this method could document colony occupancy at a large scale. The acoustic sensors were programed to record one out of every six minutes over the deployment period. Observer counts of Aleutian terns present at the deployment sites were made during the placement and retrieval of the sensors, and opportunistically throughout the breeding season. Over 5,500 hours of audio recording were collected. We developed a Deep Neural Network classification model to automate the detection and quantification of Aleutian tern vocalizations in the recordings. Our results showed that rates of vocal activity peaked during the day from 90 to 360 minutes after sunrise, but there was variation among colonies and across the breeding season. We hypothesize that these patterns illustrate the varying phenology and success of colonies. There was a positive relationship between observer counts of terns and acoustic activity rates at colonies; colony counts increased by 11.6% ± 3.5 SE (95%

CI: 4.3-19.5%) for each increase of 1 call minute^{-1} ($p = 0.002$). The results from this pilot season indicate the use of passive acoustic monitoring is a feasible way to monitor the presence and acoustic activity of Aleutian tern colonies.

WINDFARMS AND AVIAN ISSUES OVER THE OUTER CONTINENTAL SHELF OFF CALIFORNIA

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Floating platform windfarms are being considered for the Outer Continental Shelf (OCS) off California. Most existing offshore wind farms are currently anchored in shallow, nearshore Atlantic waters and avian studies conducted at these wind farms have involved nearshore species in areas with relatively uniform underwater topography. While results from these studies have been informative with respect to those areas, the OCS represents a very different environment supporting high numbers of a diverse array of seabirds due to diverse topography and strong upwelling associated with its position on an eastern boundary current (the California Current). A number of these offshore species are adapted for a highly windy, offshore pelagic environment which has resulted in flight behaviors different from many species in the nearshore environment, and many of these birds migrate long distances to exploit the resource abundance associated with the California current. This flight behavior includes dynamic soaring and "arcing" above the waters' surface during strong winds characteristic of the OCS, especially during the upwelling season, which is quite different than the typical rapid flapping, direct flight of many nearshore species. We review some of the potential wind energy/avian issues associated with the suite of species that occupy OCS waters, some approaches to risk modelling and challenges to post-construction monitoring in the OCS environment.

MERCURY CONCENTRATIONS REFLECT FORAGING BEHAVIOR OF HERRING GULLS ALONG AN URBAN GRADIENT

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Mercury (Hg) is a highly toxic heavy metal which bioaccumulates in aquatic food webs, and is a potential indicator of foraging behavior in coastal birds. The bioaccumulative form of Hg, methylmercury (MeHg), is present only in aquatic ecosystems and reaches elevated concentrations in seabird prey species. Conversely, land organisms accumulate only negligible amounts of Hg as there is no significant source of MeHg. Therefore, foraging on marine prey should result in higher Hg concentrations. Gulls (*Larus spp.*) provide a particularly suitable study model for examining how Hg relates to foraging behavior since they forage in both marine and terrestrial environments, and have a broad distribution allowing for large spatial comparisons. Urbanization influences the extent to which individual gulls rely on terrestrial

human habitats versus offshore waters to forage. We hypothesize that these differences in foraging behavior influence gull diet and ultimately Hg uptake. To test this hypothesis, we combined GPS tracking studies of herring gulls (*Larus argentatus*) with measurements of blood Hg concentrations for 54 birds at study sites along an urban gradient. We found a strong and significant positive relationship between Hg concentrations and the proportion of herring gull foraging locations occurring in marine habitats (linear regression, $R^2 = 0.51$, $p = 6.21 \times 10^{-10}$). Hg concentrations differed significantly between herring gulls whose primary foraging habitat occurred in marine versus terrestrial environments (Wilcoxon test, $p=2.42 \times 10^{-4}$). Our results suggest that Hg concentrations in blood can be used to infer the habitat use of herring gulls and likely other animals that forage in both marine and terrestrial habitats.

SPATIOTEMPORAL HABITAT USE OF RED-TAILED TROPICBIRDS BREEDING IN THE MAIN HAWAIIAN ISLANDS: A MULTI-COLONY APPROACH USING GPS TRACKING

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Studying the foraging movements and habitat use of seabirds is not only important for understanding fundamental aspects of their ecology but also for the conservation and management of marine ecosystems. This knowledge is relatively lacking among tropical seabirds. In particular, little is known about the at-sea behavior and distribution of red-tailed tropicbirds (*Phaethon rubricauda*), especially in the central Pacific where there are several breeding populations throughout the main Hawaiian Islands (MHI). We deployed GPS units on chick-rearing tropicbirds from three breeding colonies: 1) Lehua Islet off Niihau (n=16, 2015), (2) Kilauea Point National Wildlife Refuge on Kauai (n=16, 2016), and (3) Halona Point on Oahu (n=22, 2017). Along with basic movement parameters, at-sea distribution and core foraging areas were characterized using expectation-maximization binary clustering and kernel density analyses. Combining the tracking data with remotely sensed oceanographic variables, we used generalized linear mixed models to assess environmental characteristics associated with tropicbird foraging activity. The duration of foraging trips ranged from short, intra-day outings to long, multi-day trips lasting up to 10 days and reaching distances greater than 800 km from the colonies. Tropicbirds were distributed widely in waters surrounding the MHI, and they utilized distinct areas for foraging based on colony origin. Additionally, the majority of foraging habitat was encompassed by the Exclusive Economic Zone, although tropicbirds were also distributed outside its limits and coverage varied by colony. Describing at-sea ranging behaviors and foraging habitats of tropicbirds throughout the MHI is crucial for informing marine spatial planning and conservation, especially with the current interest in offshore wind energy development and threat of sea level rise to low-lying atolls.

EIGHT YEARS OF KAUA'I SEABIRD POWER LINE COLLISION RESEARCH: WHAT WE HAVE LEARNED AND WHAT NEEDS TO BE DONE

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seabird mortality from power line collisions on Kauai has been identified as one of the most significant contributors to the catastrophic historical decline of two of Kauai's endangered seabirds - the Newell's Shearwater (*Puffinus newelli)* and the Hawaiian Petrel (*Pterodroma sandwichensis)* - an issue that continues to suppress their populations. While this issue has been documented on the island since 1994, it is only recently that we have been able to model the island-wide extent of this impact. Work undertaken by the Kauai Endangered Seabird Recovery Project (KESRP) has shown that for data collected from 2013 -2015, there were 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. Here we update these estimates including a much larger data set covering the period 2012-2019. We fit separate mechanistic models of seabird collisions to observational data and acoustically detected power line strike sounds, in both cases incorporating power line characteristics as well as spatial, temporal, and environmental covariates. We compare results between these two independent data sets, and discuss the unique information provided by each set of data and the importance of considering both when assessing this critical conservation issue. For model validation purposes, we compare our results with additional modeling estimates that have been developed over the years. Lastly, we discuss the importance of implementing simple and cost-effective power line modifications that could drastically reduce the numbers of endangered seabirds killed by power line strikes on Kauai each year.

EXAMINING THE FITNESS CORRELATES OF COORDINATED PROVISIONING IN A LONG-LIVED PELAGIC SEABIRD, THE MANX SHEARWATER

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As a group, pelagic seabirds represent an extreme end of the parental care spectrum with both partners investing heavily throughout an extended incubation and then chick-rearing period. During this time, parents must balance the demands of offspring with their own energetic requirements. In some species, pairs have been observed to coordinate chick provisioning. Aside from documenting this behavior, however, the fitness implications of coordination, from both the perspective of the chick and of the adults, are unclear. We studied the chick-rearing behavior of Manx shearwaters (*Puffinus puffinus*) on

Skomer Island, Wales, in 2018 and 2019. We combined nest attendance patterns for 72 pairs as revealed by radio-frequency identification (RFID) readers along with daily chick weight measurements to assess how coordination impacted chick condition. We found that higher coordination was associated with more consistent feedings, which resulted in reduced daily chick condition variability. Additionally, higher coordination was associated with quicker growth, though peak chick mass was ultimately unaffected. For a subset of pairs (n = 15) followed in two years, the degree of coordination within-pairs was similar to between-pairs, suggesting that pairs were not consistent in this behavior. This suggests that the ability, or need, to coordinate may vary as a function of the condition of the adults. As such, our work highlights several fitness correlates of coordination, but further study focusing on how adult condition changes throughout chick-rearing is necessary to fully understand the drivers of this behavior.

MIDWAY SEABIRD PROTECTION PROJECT- THE FINAL COUNTDOWN

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The U.S. Fish and Wildlife Service (Service) will be implementing a plan to remove invasive mice from Sand Island, Midway Atoll National Wildlife Refuge. This removal is necessary to protect the largest colony of albatross in the world as well as 29 other species of birds that rely on Midway Atoll. On more than 500 other islands worldwide, similar invasive rodent removal campaigns successfully resulted in long-term benefits to native species and outweighed the limited, short-lived negative impacts from an eradication operation. The effort on Midway has many challenges including endangered non-target species, extensive infrastructure and a community of 50 people that live on the island. This presentation will provide an update on the project implementation on the effort that it has taken to get to this point. Focus will be on the challenges associated with such a complex project and creative and innovate methods that have been developed to deal with these problems. Oral or Poster

OCEAN WAVE OBSERVATION IN NORTHWEST PACIFIC BY UTILIZING BIOLOGGING DATA FROM STREAKED SHEARWATER

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Ocean waves are an essential factor in the physical interactions between the atmosphere and ocean, and may affect the animal behaviors on the ocean surface. Compared to coastal sea areas where radar observation is available, the wave observation network in the offshore waters of Japan is still poor: observations using satellites and buoys still have spatiotemporal limitations. Streaked shearwaters (*Calonectris leucomelas*) spend more than half their foraging trips on the sea surface. Here, we estimate

the ocean wave height, direction, and period by using motion data during the landing periods of streaked shearwaters on the sea surface. Ninja scans (25g, 72mm×24mm×15mm/Little Leonardo) which record GPS, velocity, acceleration, pressure, temperature, and geomagnetism were attached on streaked shearwaters breeding at the northeastern coast of Japan during summer. While the birds are on the sea surface, these data loggers record the physical characteristics of the ocean waves. The wave height was estimated from high pass filtered GPS altitude and compared to the wave height estimated from pressure. They showed great accordance in wave shape with one another. Wave direction and period were also estimated from GPS altitude and pressure combined with horizontal GPS position and horizontal velocity. The same wave properties were obtained from five independent streaked shearwaters landing in the same place at the same time. These estimated wave properties will be compared to the observation data from the meteorological buoy to verify the accuracy. Thus, we could extract wave information from motion data from landing seabirds, providing a possibility of a fine-scale wave observation system in the offshore area using seabirds.

QUANTIFYING ENVIRONMENTAL AND ANTHROPOGENIC DRIVERS OF WEDGE-TAILED SHEARWATER FALLOUT ON A COASTAL HIGHWAY ON EAST O‘AHU

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Every fledging season (November-December) in Hawaii, Wedge-tailed Shearwaters (‘Ua ‘ u Kani, *Ardenna pacifica*) are attracted to onshore streetlights, leading to disorientation, stranding, and death by vehicle collision or predation. We investigated whether a change in the highway lighting from incandescent “orange” bulbs to “white” LEDs in 2016 lead to a change in the number of grounded shearwaters. To assess variations in annual fallout, we conducted systematic road surveys to quantify grounded shearwaters along a 16-km section of the Kalaniana‘ole Highway on east O‘ahu, for 8 years: 4 before (2012-15) and 4 after (2016-19) the change of the lighting. The number of carcasses detected during surveys each year ranged from 7 to 60. A mark-recapture assessment suggests fresher (days 1 – 2) carcasses are preferentially lost to scavenging, leading to carcass underestimation by up to 50% during road surveys at 3-day intervals. This study seeks to describe spatial and temporal distribution of shearwater carcasses, investigate the environmental drivers of fallout, provide a correction for underestimation due to carcass loss, and compare fallout under two streetlight conditions. We used a multiple linear regression analysis to assess the influence of moon illumination and Julian date for each year separately and the explanatory power ranged widely, from 0-38%. This result suggests that other variables drive fallout from year to year. Going forward, we are examining the effects of wind speed, wind direction, and rainfall. Pending the analysis of the ongoing fledging season (2019), our results suggest that fallout decreased under the new streetlights, contrary to our working hypothesis of increased light attraction.

USE OF A NEW GIS APPLICATION FOR ANALYZING UAV FOOTAGE OF WATERBIRDS

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Monitoring studies of waterbirds have traditionally been ground-based, boat-based, or, more recently, conducted using small, piloted aircraft. Each of these methods comes with challenges, including cost, accuracy, and subject disturbance. Unmanned Aerial Vehicles (UAVs) have been on the market for several years now and are useful tools in the wildlife management, including research and monitoring of waterbirds. The use of UAVs has allowed biologists to survey areas of interest with less cost and ease than traditional aerial surveys (Watts et al. 2010), and has been found to result in more precise count estimates than ground or boat surveys (Hodgson et al. 2017). Footage from UAV surveys is concrete, can be used later for additional studies and monitoring, and can be checked for accuracy and quality control. Before UAVs can be implemented into regular surveying of waterbirds, however, a protocol and standard operating procedure for data collection and analysis of these data should be developed and refined. Through the use of a new ArcGIS application, Full Motion Video, users can identify and digitize birds surveyed in UAV footage. Once digitized, a dataset is produced including species, counts, and exact location of each bird, allowing for further analysis. This protocol was used for analysis of footage from three different surveys, each using different models of UAV. This protocol not only helped create a dataset from the UAV footage, but it helped minimize double-counts and found birds that were missed in the concurrent traditional survey. The use of both UAV and Full Motion Video technology can make organization and analyses of survey footage more accurate and easier to manage than alternative methods.

KEEPING UP WITH THE TUBENOSES: VEGETATIVE SUCCESSION AND SEABIRD ACTIVITY DURING PASSIVE ISLAND RECOVERY

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Islands are biodiversity hotspots but are highly sensitive to disturbances, including the introduction of predatory mammals. While there have been considerable advances to the technology used to remove invasive mammals, little is known about the changes island communities experience during recovery. New Zealand – the world's largest seabird biodiversity hotspot – has cleared mammalian predators from >100 islands over several decades, providing a unique opportunity to quantify island recovery. Here, we examine seabird and vegetative changes at Pokohinu (Burgess) Island, predator-free for almost 30 years, of the Mokohinau Islands. In 2009, we documented seabird distributions, plant diversity, and soil depth

across the island and performed smaller surveys in 2014 and 2019. We found an overall 62.5% increase in seabird burrow densities with a strong spatial overlap of species distributions. Diversity of plant species also significantly increased, possibly due to the increased abundance of seed-dispersing birds and the simultaneous expansion of invasive plant species. In addition, we performed burrow and vegetation surveys at other Mokohinau Islands that lack same extent of past human disturbance as Pokohinu, which is a retired lighthouse and farm. Seabird densities between islands were comparable but plant communities lacked many of the invasive species found at Pokohinu. Overall, our results suggest that vegetative cover might not be limiting nesting habitat availability within the Mokohinaus, as seabirds are able to utilize areas dominated by dense vegetation. We emphasize the importance of understanding vegetative succession during recovery periods which may help explain recolonization rates for more specialist species.

DIVISION OF LABOR BY SEX IN ATLANTIC PUFFINS DURING PERIODS OF GOOD AND POOR FOOD CONDITIONS

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We followed chick provisioning and burrow guarding behavior of three Atlantic Puffins (*Fratercula arctica*) at Seal Island NWR, Maine during good and poor chick rearing years. Willie, a 17-year old male, occupied a burrow with a high definition web cam in 2016 and reared a chick there over the next three years. In 2017, Willie and mate Billie provisioned 31% and 69% of feedings, respectively. Willie was the main guardian, accounting for 66% of parent time in the burrow. Early in 2018, Willie and Billie provisioned at normal rates, but feedings declined with the onset of high SST in mid-July. Prior to the heat wave, Willie provisioned 33% of feedings and assumed the majority share of in-burrow care, as in 2017. As feeding rate declined, both parents focused on foraging, with Willie's feedings/day comparable to, or exceeding Billie's. During this time, neither pair occupied the burrow. In 2019, Willie paired with a different female, Millie, and returned to his role of chick and burrow guarding with 70% of parent time in the burrow. He provided a minority 32% of feedings. These observations suggest gender specific roles in puffin parents, with the female serving as the primary provisioner and the male providing more chick care and burrow guarding. Our observations suggest that when provisioning conditions deteriorate, male Atlantic Puffins will trade burrow guarding time for additional effort to provision the chick. While this may help fledge the chick, it may also have consequences for retaining a burrow and mate in future years.

NEW PROGRESS ON THE CONSERVATION PROJECT OF CHINESE CRESTED TERN

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Chinese Crested Tern (CCT) is a critically endangered seabird and distributed in western Pacific. So far it mainly breeds within colonies of Great Crested Tern (GCT) on 2 islands of Zhejiang Province, East China Sea. The ornithology group of Zhejiang Museum of Natural History has been studying and conserving CCT since 2003. Banding of the chicks of CCT and GCT started in 2015, and from 2017 we began to put GPS trackers on GCT and CCT to study the migration routine. By the August of 2019, 903 chicks of GCT and 5 chicks of CCT were banded in total, GPS trackers were put on 15 adults of GCT and 1 adult of CCT. And the maximum calculation of CCT in the breeding area of Zhejiang this year is 77 adults and 25 chicks, the population shows a slow but continuous increase. By the information gained from GPS trackers and eye-witness reports along the coastline of China, we found that 1) the adults and chicks of CCT migrate together, one chick follows one parent at least; 2) CCT is speculated to migrate along the coastline of China, before and after breeding season.

OCEANIC DRIVERS OF HABITAT USE IN BREEDING RHINOCEROS AUKLETS (CERORHINCA MONOCERATA) FROM SOUTHEAST FARALLON ISLAND

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Gaining a better understanding of the drivers that influence seabird distributions is crucial for developing conservation action and protecting critical marine habitat. Within the California Current Large Marine Ecosystem (CCLME), nesting seabirds from the Farallon Islands forage in nutrient rich waters but are susceptible to fluctuations in local oceanographic conditions, especially during El Niño events. Here we used GPS loggers (2015-2017) or a combination of GPS and time-depth recorders (TDR; 2018-2019) to investigate potential patterns of interannual variation in habitat use by breeding rhinoceros auklets Cerorhinca monocerata (n=47) from Southeast Farallon Island. Hidden Markov Models were used to delineate behavior states from GPS data, whereas diving data obtained from TDRs were used to characterize foraging activity. Temporally matched, remotely-sensed oceanographic data (sea surface temperatures (SST), chlorophyll-a, bathymetry, and distance to continental shelf) were appended to GPS and behavior states. Generalized Linear Mixed Models will be used to identify interactions between auklet foraging locations and local oceanographic conditions. Given the two El Niño events occurred within our study period (2015 and 2019), we predicted that auklet distributions expanded with warmer SSTs and lower ocean productivity – forcing larger search efforts for resources. In preliminary results, we found that auklets tracked in 2017 made longer trips ($\bar{x}$ =97.9 km/trip; $\bar{x}$ = 14.9 hrs/trip) while auklets tracked in 2018 traveled further from the colony ($\bar{x}$ = 77.9 km). While data analyses are ongoing, we aim to increase our understanding of seabird behaviors at-sea and identify critical habitat for conservation.

A BASELINE APPROACH TO ASSESSING TAXON-SPECIFIC SUSCEPTIBILITY TO OIL SPILLS

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Oil spills can lead to short-term intense impacts on seabirds. Seabird species may vary in their response to spills due to differences in diet, feeding methods, range, and other life history traits. In past research, assessing species susceptibility has been estimated based on oiled taxon abundance during a spill. However, this method assumes more is always worse, when in reality a species that is abundant in a spill could simply be a highly abundant species for that location and time of year. We investigated taxon-specific susceptibility using mortality data from the *Nestucca* and *Tenyo Maru* oil spills compared to a seasonal and spatially overlapping baseline data set from the Coastal Observation and Seabird Survey Team. Cluster analysis and Principal Coordinates Analysis revealed patterns in variation in species composition in spill and non-spill years. To identify which species appeared to be at elevated proportions in oil spills relative to their baseline, we developed a novel technique comparing species proportions between spill and non-spill years. In general, inter-annual variability in the baseline is high, indicating that a decade or more of baseline data are essential. Spill years are encapsulated in the baseline but tend towards the extreme of their respective cluster. For each spill, clustering between years is driven by about three to five taxa. When proportions are examined at the taxon-specific level, dominant species tend to be highly at risk or highly safe, while rarer species tend towards slightly safe, although this method has a reduced capacity to detect trends in rare species. We provide both insight into the *Tenyo Maru* and *Nestucca* oil spill and methods that can be extended to other spills.

SEABIRDS AS NATURAL PARTNERS IN MAXIMIZING ISLAND ECOSYSTEM RESILIENCE TO CLIMATE IMPACTS

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Seabirds play an important connectivity role for terrestrial and marine ecosystems through allochthonous nutrient transfer. Here, we present a conservation intervention leveraging a seabird-driven land-sea connection to enhance an atoll's resilience to climate impacts. In April 2019, The Nature Conservancy, U.S. Fish and Wildlife Service, and Island Conservation initiated the Palmyra Atoll Rainforest and Reef Resilience Project to maximize the quantity and distribution of seabird-derived nutrients subsidizing primary productivity on land and in nearshore marine habitats. Palmyra Atoll, an

incorporated, unorganized U.S. territory supports the only protected rainforest in the region. This conservation action entails replacing the atoll's estimated 27,000 coconut palms (covering > 40% of forested land) with native tree species preferred by seabirds as roosting and nesting habitat. Research conducted at Palmyra shows a significant relationship between seabird-derived nutrients (guano) and primary productivity in both terrestrial and coral reef systems. We are using Unmanned Aerial Systems (UAS) and other standard monitoring methods to measure change in seabird distribution and abundance in response to rainforest realignment along with repeat measures of nutrient concentrations in submarine groundwater discharge to track change in seabird-derived nutrient subsidies to the marine environment. We expect coconut palms controlled and native trees established within two years of project initiation, and a mature forest canopy within 15 years. With this conservation intervention, we hope to establish a climate adaptation tool for other seabird islands previously converted to copra plantations.

A COMPARISON OF TRACKING TECHNOLOGIES TO DOCUMENT FORAGING HABITAT OF ARCTIC AND COMMON TERNS

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Seabird colony managers need detailed information on seabird foraging behavior to better understand resource use, habitat selection, energetic constraints, and to understand susceptibility to environmental change including climate change and wind energy development. For the past eight years, Maine Coastal Islands National Wildlife Refuge, has been working to document Arctic tern (*Sterna paradisaea*) and common tern (*S. hirundo*) foraging habitat, colony attendance patterns, and post-breeding movements in the Gulf of Maine. Working on five different colonies, we have utilized coded nanotags and automated receiving stations, satellite tags, and most recently, GPS loggers to track the terns. While each technology provided valuable information, we found that the data quality differed significantly among the technologies. Nanotags provided the finest scale information on foraging effort and colony attendance, but failed to identify foraging areas. Satellite tags provided limited data on foraging areas, but provided critical information on staging, migration, and wintering patterns. GPS loggers provided the most accurate information on foraging behavior, but data collection was dependent on the terns returning to the breeding colony. Selection of an appropriate tracking technology must consider bird size, cost, location of the colony, level of movement detail needed, and geographic scope of concern.

INCREASED SUMMER FOOD SUPPLY DECREASES MIGRATION DISTANCE IN BLACK-LEGGED KITTIWAKES

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Individual condition at one stage of the annual cycle is expected to influence behaviour during subsequent stages, yet experimental evidence of food-mediated carryover effects is scarce. We used a food supplementation experiment to test the effects of food supply during the breeding season on migration phenology and behaviour. In this three-year study (2009-2011), we provided an unlimited supply of fish to black-legged kittiwakes (*Rissa tridactyla*) during their breeding season on Middleton Island, Alaska, monitored reproductive phenology and breeding success, and used light-level geolocation to observe nonbreeding behaviour. Among successful breeders, fed kittiwakes departed the colony earlier than unfed controls. Fed kittiwakes travelled less than controls during the breeding season, contracting their nonbreeding range. Our results demonstrate that food supply during the breeding season can have carryover effects on nonbreeding phenology, movement, and distribution.

EVOLVING METHODS: DIGITAL PHOTOGRAPHY FOR CONDUCTING AERIAL AT-SEA SURVEYS OF THE PACIFIC OUTER CONTINENTAL SHELF OFF CA, USA

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The U.S. Geological Survey's Western Ecological Research Center, with support from the Bureau of Ocean Energy Management, is conducting digital aerial photographic surveys of the Pacific Outer Continental Shelf (POCS) off central and southern California from 2018–2021. Recent technological advances make it possible to collect high-resolution digital images and other remotely sensed data from small aircraft in real time, but methods are in the early stages of development for marine wildlife at-sea aerial survey applications. Use of photographic methods provide an archivable record of imagery captured along transects, which can be evaluated later through development and use of machine learning. This project conducts flights with three DSLR cameras at 305 m AMSL, which corresponds to an effective strip width of ~250 m, and image resolution of 1 cm per pixel, while minimizing disturbance to marine wildlife. A micro radar altimeter and an inclinometer are used to record height above sea level and camera angles. These data are used to quantify inherently variable image footprint size, overall survey effort, and ultimately the density of the taxa documented. In addition to providing information to compare with historical surveys with the goal to inform renewable energy development in the POCS, this project will help to develop resources and methodologies to increase the standardization and efficiency of future aerial photographic surveys.

LOW USE OF CAY SAL BANK TO TRANSITING BROWN PELICANS DESPITE APPARENT AVAILABILITY

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Transiting across inhospitable environments can act as a significant energetic stressor for migrating species, especially for those traversing long distances. Locations offering rest and the potential for resource acquisition within hostile environments can therefore be of critical importance for species attempting long-distance movements. We studied the migration patterns of Eastern brown pelicans (*Pelecanus occidentalis carolinensis*) in the Gulf of Mexico and South Atlantic Bight from 2013-2019, including movements from mainland Florida to Cuba, using GPS satellite transmitters. Cay Sal Bank, Bahamas, is a critical breeding ground for several seabird species and lays approximately halfway between departure points in the Florida Keys and arrival points in Cuba. Despite migrating individuals being highly proximate to Cay Sal Bank, we found a low incidence of use, with most individuals instead undertaking a non-stop flight across the Florida Straits. We suggest that Cay Sal Bank may not be suitable as a stopover location for migrating pelicans despite hosting numerous other seabird species for reasons that are still unclear.

¡FIESTA, FIESTA TODA LA NOCHE! RESTORING GLOBALLY ENDANGERED PERUVIAN DIVING-PETREL TO ONCE EXTIRPATED ISLA CHAÑARAL, CHILE

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The Peruvian Diving-petrel (*Pelecanoides garnotii*), or yunco, is endemic to the Humboldt Current System, where it was once considered one of the most abundant seabirds. Today this species, nesting on just six of its original breeding islands, is considered globally threatened (listed as Endangered by IUCN Red List) due to impacts from guano extraction and predation by invasive mammals. Isla Chañaral once hosted the largest breeding population of yuncos in Chile (~100,000 pairs), however, this population was presumably extirpated by introduced foxes in the 20th century. Today, nearby Isla Choros, 16 km from Chañaral, has the largest breeding population of yuncos in Chile, and both Choros and Chañaral are free of invasive vertebrates. In September 2019, prior to the peak of the reproductive season, we initiated a social attraction project to facilitate the recolonization of Chañaral. We surveyed and evaluated 15 potential restoration sites (based on habitat characteristics and knowledge of historical nesting). At the

two sites deemed most suitable, we deployed sound systems and artificial burrow entrances plus camera traps to monitor yunco visitation. We deployed cameras at two additional sites not subject to social attraction to evaluate the effectiveness of our methods. Images collected from the first five weeks after the social attraction equipment was deployed showed yuncos visiting both sites over multiple nights. These early results are strong positive indicators that our methods are working and give us confidence that the Chañaral population can be restored and provide an important recovery milestone for this globally threatened seabird.

USING STABLE ISOTOPE ANALYSIS TO DOCUMENT EFFECTS OF WARMING OCEANS ON DIET OF THE MARBLED MURRELET (*BRACHYRAMPHUS MARMORATUS*)

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As anomalous warm ocean events are becoming more prolonged and numerous in the Northeast Pacific ocean, trophic level decline has been observed in several seabird species due to the reduction of prey quality and availability. Understanding the impact of this decline on the breeding and recruitment of the Marbled Murrelet, an endangered seabird species, is essential to population forecasting and recovery efforts. To capture the impact of the warm ocean events on the Marbled Murrelet, we tested temporal changes in isotope signatures of $\delta^{15}N$ and $\delta^{13}C$ in feathers and red blood cells collected from 240 individual murrelets captured off the central Oregon coast in spring 2016-2019. Nitrogen and Carbon obtained from prey items are incorporated into body tissues and can be used to track general changes in trophic position (N) and the type of prey items consumed (C), as well as quantify fine-scale temporal changes in N and C by sampling structures grown at different times in the annual cycle (e.g., feathers). By analyzing breast and secondary feathers and red blood cells for $\delta^{15}N$ and $\delta^{13}C$ and comparing our results with known stable isotope signatures of prey items, we identified changes in diet across August 2015 – May 2019, which included an anomalous warm ocean event that persisted through the summer of 2016. These results provide insight into how murrelet diet will respond to changing ocean conditions as warm ocean events increase in frequency and severity.

USING THERMAL IMAGING DRONES TO SURVEY CRYPTIC BURROW-NESTING SEABIRDS

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Burrow-nesting petrels and shearwaters include some of the seabird species most vulnerable to extinction and species with some of the largest knowledge gaps. Much of this is due to their cryptic, nocturnal habits and their tendency to nest in underground burrows that are often in inaccessible locations. Locating nests, or in some cases even entire colonies, can be difficult. The use of unoccupied aerial vehicles (drones) in conservation biology has accelerated in recent years, but few studies have examined the potential to combine traditional visible spectrum photography with infrared thermal imaging to survey wildlife. We tested the use of thermal imaging cameras mounted alongside traditional RGB cameras to detect the heat signatures of cryptic burrow-nesting seabirds. We conducted six test flights of a quad copter drone with a dual sensor RGB/infrared camera over survey plots in a Wedge-tailed Shearwater colony prior to sunrise at Kaena Point, Oahu, Hawaii. Within one hour of the flights, we then manually counted the burrows in each plot and confirmed their contents to verify the drone results. Initial results indicate the thermal images taken by the drone were able to detect the presence of birds in burrows by the signature of heat venting from the burrow entrance. Burrows were detectable at an altitude of up to 10m in this colony, despite a small difference between the ambient temperature and the birds . This technique can be expected to perform better in cooler climates with larger thermal gradients. Enhanced monitoring tools are needed to provide more information about seabirds and guide conservation efforts, and the results from this study can be broadly applied to other cryptic birds, mammals, and habitats.

PRELIMINARY STUDY RESULTS OF SATELLITE TRACKING OF GREATER CRESTED TERNS FROM THE ISLAND OF SERAM, THE MALUKU ISLANDS, INDONESIA

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The Greater Crested Tern (*Sterna bergii*) is a widespread species that is found from southern Africa through the Indian Ocean to the western and central Pacific Ocean. They are one of several terns and other seabird species that spend their non-breeding season in eastern Indonesia. Beginning in 2018, our team has tagged five Greater Crested Terns along the northern coast of Seram Island, in the Maluku Province of eastern Indonesia, to study the habitat use and migration of this species. We used solar recharging satellite PTT tags and tracked individuals 9-14 months with tracking of two individuals still ongoing. To our knowledge, this represents the first seabird tracking effort in Indonesia. The adult birds were found to migrate to the Gulf of Carpentaria of Australia between February/March to June/July while the immature birds moved to the Banda Sea and offshore of the Northern Territory, Australia between June to September. All individuals displayed fidelity to the northern coast of Seram, returning to that area following breeding season migrations. Further analysis of the tracking data will help us to identify important sites to terns and seabirds in eastern Indonesia.

SEABIRD MONITORING INPUTS TO ECOSYSTEM ADVICE FOR FISHERIES MANAGERS

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Scientists have been providing contextual ecosystem information to federal fisheries managers in Alaska to support the quota-setting process for 25 years. This information is supplemental to the stock assessment process and largely consists of ecosystem indicators that track physical and biological changes in the ecosystem. Seabird information is used in several ways by the North Pacific Fisheries Management Council each year. Some long-term monitoring datasets (diet, breeding success) are regularly included in ecosystem status reports as indicators of different parts of the ecosystem. Additional indicators are curated each year to allow early communication to managers of warning signs covering a variety of trophic levels. In 2018, this type of communication provided information of strong impacts on the northern Bering Sea ecosystem, which did not freeze over during the preceding winter for the first time, to stock assessment scientists and fisheries managers before stock assessments were completed. The rapid availability of this information informed a re-evaluation of stock assessment assumptions regarding a geographic shift of fish stocks. Since 2018, many stock assessments have included new risk tables that identify and rank assessment model, population dynamics, and ecosystem concerns, including information from seabirds. Seabird managers have realized increased support for long-term monitoring programs when data can be directly used for management. In this presentation we share lessons learned in the process of informing fisheries management with seabird information. Collaboration among seabird biologists and fisheries managers enhances understanding in real time about important marine ecosystem changes.