

## ANTI-CYCLONIC CIRCULATION AND THE LONG-RANGE FORAGING MOVEMENTS OF HAWAIIAN PETRELS (*PTERODROMA SANDWICHENSIS*) IN THE NORTH PACIFIC

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Satellite telemetry studies of the movements of seabirds are now common and have revealed impressive flight capabilities and extensive distributions among individuals of many species at sea. Linking seabird movements with environmental conditions over vast expanses of the world's open ocean, however, remains difficult. We applied a new method for quantifying the movements of far-ranging seabirds in relation to ocean winds measured by the SeaWinds scatterometer onboard the QuikSCAT satellite. We apply vector correlation to evaluate how the trajectories (ground speed and direction) of Hawaiian Petrels outfitted with satellite transmitters during the summer chick-rearing period were related to ocean winds. During three consecutive breeding seasons (2006–08), 17 birds from two colonies (Maui and Lanai) completed 23 clockwise, circular, long-distance  $9716 \pm 418$  SE km foraging trips lasting  $18.0 \pm 0.9$  days. We suggest that low variability in foraging trip distance ( $cv = 0.17$ ) and duration ( $cv = 0.19$ ) results from the petrels' reliance on quartering tail-winds as they circle large anti-cyclones located to the north of Hawaii in the central-eastern North Pacific. Two tagged individuals classified as non-chick provisioning adults attending nest sites, and one individual outfitted with a transmitter who was not recaptured (all lost transmitters at sea) completed long-range, clockwise excursions into the North Pacific, similar to the completed loops of chick provisioning adults, but once southeast of the main Hawaiian Islands, all three exhibited meandering paths south to the North Equatorial Counter Current (NECC) and west as far as the Philippine Sea. Limited data from these individuals indicate that adults may seek productivity associated with the NECC and western Pacific during the winter non-breeding season.

## PACIFIC CONTINENTAL SHELF ENVIRONMENTAL ASSESSMENT (PACSEA): SEABIRD AND MARINE MAMMAL SURVEYS OFF THE NORTHERN CALIFORNIA, OREGON, AND WASHINGTON COASTS

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Interest has increased for developing renewable energy sources to reduce U. S. dependence on oil. Some policy makers include power generation along the continental shelf of the U. S. Pacific coast, beyond state waters. This region supports abundant populations of seabirds and marine mammals, but comprehensive, multi-seasonal aerial surveys were conducted two decades ago. Marine spatial planning, including potential site selection for offshore energy development, requires the description and quantification of recent species-specific and community patterns in distribution. To relate patterns of seabird abundance to physical and biological characteristics of ocean habitats, we conducted low-elevation aerial seabird surveys during January, June, and October 2011 (and continuing in 2012) along parallel strip-transects spanning continental shelf and slope waters from Fort Bragg, CA to Grays Harbor WA. Although effort focuses on Federal Waters outside of the 3-nautical mile state boundary, surveys include inshore waters to allow comparisons both within and adjacent to potential renewable energy developments. In the past, environmental analyses of aerial seabird surveys have relied on satellite-derived products of ocean optical properties that are coarse in scale or temporally-averaged to produce better spatial coverage. Therefore, in addition to aerial pyrometry to measure sea-surface temperature, we installed an on-board hyperspectral radiometer to collect remotely-sensed reflectance simultaneously with species observations. Herein, we discuss survey methods and describe inter-seasonal trends in abundance and distribution for marine birds and variability in the ocean environment, and introduce aerial hyperspectral radiometry as a potential tool for delineating fine-scale ocean habitat features (fronts and watermasses) based on ocean color.

#### CASPIAN TERN (*HYDROPROGNE CASPIA*) FORAGING ECOLOGY AND PREDATION ON JUVENILE SALMONIDS IN SAN FRANCISCO BAY, CALIFORNIA

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Brooks Island in San Francisco Bay is a proposed relocation site for some Caspian Terns (*Hydroprogne caspia*) currently nesting in the Columbia River estuary. A bioenergetics modeling approach and radio-tracking of Caspian Terns nesting on Brooks Island in 2008 and 2009 were used to estimate consumption of Endangered Species Act-listed juvenile salmonids (*Oncorhynchus* spp.) and examine availability of other forage fish resources. Estimated salmonid consumption was ca. 205,000 smolts in 2008 and ca. 167,000 smolts in 2009. Estimated predation rates on threatened Central Valley spring-run Chinook (0.1%) were lower than those on unlisted fall-run Chinook (1.0%). Assuming mortality from Caspian Tern predation is 100% additive, the proposed enhancement of the colony to 3,000 individuals would at most cause declines in annual population growth rates ( $\lambda$ ) of 0.02% for spring-run Chinook and 0.28% for fall-run Chinook. The median foraging distance from the colony was greater in 2009 compared to 2008 (20.6 km vs. 14.0 km), average number of foraging trips per day was higher (4.4 vs. 3.4 foraging trips), and average adult colony attendance was lower (43% vs. 52% of daylight hours). Caspian Terns used a number of core foraging areas within 30 km of Brooks Island, one overlapping with a release site for juvenile salmonids in eastern San Pablo Bay. Individual Caspian Terns

displayed foraging site fidelity, suggesting that foraging at the hatchery release site for salmonids is a learned behavior. Consumption of juvenile salmonids by Brooks Island terns would be largely curtailed by modification of hatchery release practices.

## MODELING THE DEMISE AND REBIRTH OF WEST MAUI'S NEWELL'S SHEARWATER AND HAWAIIAN PETREL COLONIES

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Several hundred endangered Hawaiian Petrels (HAPE, *Pterodroma sandwichensis*) and <100 threatened Newell's Shearwaters (NESH, *Puffinus auricularis newelli*) remain in colonies in West Maui, Hawaii. These may be genetically distinct populations, raising issues for endangered species' recovery programs that seek preservation of genetic diversity. Population modeling indicates that HAPE and NESH could be extinct from West Maui within three decades and two decades, respectively. On the basis of interest and resources, First Wind, as mitigation for the Kaheawa Wind Power I and II wind energy projects, propose to reverse extinction of these two species from West Maui by establishing predator-free colonies. As part of that effort, we developed a deterministic population dynamics model, with demographic values taken from the literature, for evaluating growth of 'artificial' colonies at Makamaka'ole (West Maui). Modeling results and experience with similar projects in New Zealand show that reversing the trend is possible, if this mitigation option is implemented soon. Through "social attraction," these new artificial colonies would "borrow" recruits from the decreasing nearby colonies. The new colonies would experience growth quickly, but existing colonies would experience an increased rate of decline. Overall however, based on population modeling, the species populations' trends would change from decreasing to increasing within 30 years, despite the hastened population decrease in the existing colonies. Within 20-30 years, depending on species, self-sustaining, growing colonies of HAPE and NESH should exist once again in West Maui.

## FATAL LIGHT ATTRACTION AND SAVE OUR SHEARWATERS

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Young federally threatened Newell's Shearwaters (*Puffinus newelli*) and Hawaiian Petrels (*Pterodroma sandwichensis*) fledging from their natal burrows in the mountains become confused and unable to navigate when confronted with urban light arrays. This "fatal light attraction" results in disoriented birds circling lighting structures until they are exhausted and "fallout" to the ground. Once grounded, the young birds are vulnerable to predators, vehicles, dehydration and starvation. In 1979, the State of Hawaii responded to seabird fallouts by establishing several aid stations (unmanned drop-boxes) on Kauai and encouraging members of the public to take grounded seabirds to the aid stations. Initially, nearly 2,000 young shearwaters were picked up seasonally by Kauai residents. These birds were then collected, banded and released by the Department of Land and Natural Resources.

According to Kauai seabird biologists, Newell's Shearwater and Hawaiian Petrel numbers are in steep

decline. Pressure is rising to ensure that every rescued fallout bird is given the best chance of survival post-release. Since 2009, additional base-line information has been gathered from these birds including basic blood values, body condition scores and behavioral observations. Protocols for “best practices” rehabilitation techniques, waterproofing and release requirements have been established to ensure birds are prepared for pelagic life. Morphometric measurements, observational data, weight values and banding contribute to the effectiveness of rehabilitation and to the accumulation of normal biological reference data for these species.

## POPULATION GENETIC STRUCTURE OF THE BLACK-FOOTED ALBATROSS IN NORTH PACIFIC

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The Black-footed Albatross *Phoebastria nigripes* population on the Hawaiian Islands, which have more than 95% of the total population of the species, is currently stable. However, the population may be at a risk of decline due to fishery bycatch and loss of low-lying breeding colonies associated with rise of sea level in global warming. In contrast, the population in the western North Pacific regions such as the Bonin Islands is rapidly increasing, and the breeding areas are expanding. The breeding distribution of the Black-footed Albatross may change during in the near future. To estimate population dynamics based on population genetic structure, we performed genetic analysis on the six colonies of the Black-footed Albatross in the North Pacific: Izu-Torishima (n=50), Bonin (n=77), Kure (n=11), Midway (n=48), Tern (n=48) and Laysan (n=48) using 10 microsatellite markers.

Central and western North Pacific populations were strongly genetically differentiated. Each side population has several private alleles. In contrast to the case of the Laysan Albatross *Phoebastria immutabilis*, western population of the Black-footed Albatross seems to have survived from serious human disturbance in early 20<sup>th</sup> century and maintained genetically unique population.

The exception was Kure Atoll: the west end of the Hawaiian Islands, which maintained gene flow with both central and western North Pacific populations. This may due to recent colony expansion of western population. This result may indicate the sign of distribution change in central and western North Pacific populations of the Black-footed Albatross.

## SEABIRDS AS ADHESIVE SEED DISPERSERS OF ALIEN AND NATIVE PLANTS IN THE OCEANIC OGASAWARA ISLANDS, JAPAN.

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Previous studies have shown that long-distance dispersal of plants to oceanic islands was largely attributed to birds. While frugivorous land birds have received much attention as seed dispersal agents, there have been only a few studies on adhesive dispersal by birds. Here, we examine the dispersal ability of seabirds, which are possibly effective seed dispersers by adhesion due to their extensive mobility and large population sizes at breeding sites. In the Ogasawara Islands, Japan, we used capture surveys of the black-footed albatross (*Phoebastria nigripes*), the Bulwer's petrel (*Bulweria bulwerii*), the wedge-tailed shearwater (*Puffinus pacificus*), and the brown booby (*Sula leucogaster*) to examine the occurrence of seed adhesion to their bodies and tested the salt tolerances of the seeds. In addition, the distributions of the plant species were investigated and relationships between plant and seabird distributions were analyzed using generalized linear mixed models and generalized linear models. Seeds of nine plant species including alien species such as *Cenchrus echinatus* and *Boerhavia diffusa* were detected on approximately 15–30% of captured seabirds. They included seeds that were generally considered to be dispersed by wind or internal transport by birds. Seeds exposed to NaCl solution isotonic with seawater for up to eight hours suffered little or no loss of viability. Analyses of plant distributions suggested that seabirds affect the distributions of the plants. Our study shows that seabirds are effective seed dispersal agents for both of native and introduced species. This is the first systematic study on adhesive dispersal by birds.

## ENDANGERED 'UA'U AT HALEAKALA: A STORY OF SUCCESS

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Attempts to document nesting endangered 'ua'u (Hawaiian petrel, *Pterodroma sandwichensis*) at Haleakala National Park began in the early 1960's. At that time, observers found 15 nests, and estimated the population at approximately 300 individuals. The observers noted large numbers of depredated carcasses and collapsed nests. The National Park Service thus began low-level predator and ungulate control in the 1970's. Research in the 1980's showed that predation was limiting the growth of the population. Additionally, ungulates were destroying habitat. The National Park Service began aggressive feral animal and predator control in the early 1980's. Population monitoring shows that this aggressive and on-going management results in increase of endangered 'ua'u population. Haleakala is now home to over 1,600 known nests. Based on population monitoring and GIS monitoring, the current estimated population of 'ua'u at Haleakala is 9,000 individuals.

## TROPICAL SEABIRD BIOLOGY AND CONSERVATION: SETTING THE STAGE FOR THE SYMPOSIUM

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Tropical oceans (surface temperatures  $\geq 23^{\circ}\text{C}$ ) include a greater proportion of the world's oceans than any other. Low productivity is a defining feature of these ecosystems. "Tropical" seabirds include species that breed in tropical latitudes and species that feed there. For seabirds that feed in tropical waters, low productivity has profound consequences with respect to wing morphology that ultimately drive foraging strategy. In general, these seabirds must have energetically efficient flight in order to cover large areas in search of prey that are patchy in space and time. The ability to use flight-efficient wings for locomotion in water is compromised, so severely in some species that they rarely (if ever) land on the water surface. It follows that tropical seabirds generally are restricted to feed in association with mechanisms that concentrate prey at or near the air-water interface (though depth of dive tags are proving that some species dive deeper than has been generally believed). Feeding strategies, and so, wing morphology and ultimately low productivity, also have profound implications for conservation of tropical seabirds. In particular, fisheries bycatch, often the most serious threat to seabirds that feed outside of the tropics, is less of a concern. Instead, because large predatory fishes are a significant "resource" for seabirds because they chase and hold prey fishes and invertebrates near the water surface, depletion of these marine predators through direct fisheries worldwide represents an indirect but consequential threat to tropical seabirds that is rarely considered outside the world of seabird managers.

## MARBLED MURRELETS IN SPACE?

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At-sea research on Marbled Murrelets (*Brachyramphus marmoratus*; hereafter murrelets) has been dominated by observational surveys that provide little understanding of individual space use. To quantify spatially unbiased metrics of marine space use, we used radio telemetry to record nest and at-sea locations during the breeding season in 2007 and 2008 at Port Snettisham, Southeast Alaska. Fixed kernel density (FKD) estimates of home range size (95% FKD) were larger on average ( $F_{3,69} = 7.85$ ,  $p = 0.007$ ) in 2008 ( $158.6 \pm 17.6 \text{ km}^2$ ;  $n = 37$ ) than 2007 ( $97.9 \pm 9.8 \text{ km}^2$ ;  $n = 35$ ). Core use areas (50% FKD) were not randomly distributed in our study area; rather they were concentrated in two hot spots at Port Snettisham in 2007. Hotspots increased in number in 2008, including small hot spots near the mouth of Tracy Arm to the south. Mean commuting distance from at-sea locations to nest sites was longer ( $t = 3.32$ ,  $p = 0.003$ ) in 2008 ( $20.0 \pm 2.0 \text{ km}$ ) than 2007 ( $12.0 \pm 0.9 \text{ km}$ ), and murrelets nesting further from the coast reduced their foraging ranges in 2008 when foraging conditions were less favorable. On average, home range size

was smaller and commuting distances to nests were shorter than previous estimates elsewhere, suggesting that Port Snettisham provides relatively high quality foraging habitat. Nonetheless, inter-annual differences in murrelet space use were evident and annual variation is an important factor when considering the distribution of murrelets at sea in Southeast Alaska.

## BIOGEOCHEMICAL INDICATORS OF CHANGE IN HIGH- AND LOW-ARCTIC MARINE BIRD COMMUNITIES: COMPARATIVE ISOTOPIC ( $^{13}\text{C}$ , $^{15}\text{N}$ , AND $^{34}\text{S}$ ) STUDIES IN ALASKA AND GREENLAND

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Understanding the complex dynamics of environmental change in northern latitudes is particularly critical for Arctic avian communities, which are integral components by which biological teleconnections are maintained between the mid and northern latitudes. Furthermore, Arctic birds are fundamental to Native subsistence lifestyles and a focus for conservation activities. Avian communities of marine and terrestrial Arctic environments represent a broad spectrum of trophic levels, from herbivores (eg., geese *Chen* spp.), planktivores (eg., auklets *Aethia* spp.), nearshore and offshore fish (eg., cormorants *Phalacrocorax* spp, puffins *Fratercula* spp.), even other bird species (eg., gulls *Larus* spp., falcons *Peregrinus* spp.). This diversity of trophic interconnections is an integral factor in the dynamics of Arctic ecosystem ecology, and they are key indicators for the strength and trajectories of change. Since 2009, we have been studying the foodweb ecology using stable isotopes ( $\delta^{13}\text{C}$ ,  $\delta^{15}\text{N}$ ,  $\delta^{34}\text{S}$ ) of contemporaneous coastal and marine bird communities in High Arctic (Northwest Greenland) and Low Arctic (western Aleutian Islands, AK). Although geographically distant, these communities comprise similar taxonomic and ecological congeners, including several species common to both (eg., Common Eider, Black-legged Kittiwake, Northern Fulmar). Generally, High Arctic species have tissues that are more enriched in  $\delta^{15}\text{N}$  compared to their Low Arctic counterparts, but  $\delta^{13}\text{C}$  values are similar in both regions. These patterns are probably related to isotopic variations in food rather than trophic level differentiation. Both Low- and High-Arctic bird communities show decadal-period shifts in stable isotope profiles, based on prior published results and previously collected specimens.

## COMPARISON OF STABLE ISOTOPE TECHNIQUES USING SEABIRDS OF THE NEAR ISLANDS, ALEUTIAN ISLANDS

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Stable isotope analyses are often used to infer migration patterns, diet composition and trophic status of seabirds. Many techniques are used to analyze stable isotopes among and within tissues, which potentially affect the results, their interpretation and thus the comparability of studies. One such difference is seen with the processing of lipids in samples. Tissues contain variable amounts of lipids that are depleted in the heavy carbon isotope ( $^{13}\text{C}$ ) and may introduce a bias in these values. There is evidence that lipid extraction may affect other stable isotope ratios, such as  $\delta^{15}\text{N}$ . Consequently, correction factors need to be applied to appropriately interpret  $\delta^{13}\text{C}$  and  $\delta^{15}\text{N}$  values for individual species and tissue type. In this study, we collected seven species of seabirds from the Near Islands, the western most group of islands in the Aleutian Island archipelago. We sampled kidney, liver, heart and muscle samples from each bird and after freeze drying, individual tissue samples were divided into two subsamples. We left one subsample unaltered and extracted lipids from the other subsample using a 2:1 chloroform-methanol solution. We found that  $\delta^{13}\text{C}$  values varied among species and tissue type by as much as 1 ‰, while  $\delta^{15}\text{N}$  values remained fairly robust. Ultimately, the correction factors calculated for these seven seabird species will contribute to the growing body of knowledge regarding the effects of lipids on stable isotope ratios.

#### NIGHT BIRDS RETURNING: A COLLABORATIVE EFFORT TO RESTORE SEABIRD NESTING HABITAT IN GWAII HAANAS NATIONAL PARK RESERVE AND HAIDA HERITAGE SITE

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Gwaii Haanas National Park Reserve and Haida Heritage Site, cooperatively managed by the Haida Nation and the Government of Canada (Parks Canada), has identified introduced species as the primary threat to ecological integrity of the park reserve. Management of invasive species, including invasive rats, is an agency priority. In 2009, in an effort to restore 10 seabird nesting islands (~800 ha), a 5-year, 2-phase project to eradicate two species of rats was initiated. Islands were selected based on their historic seabird nesting values, with an objective to restore nesting habitat for Ancient Murrelets (translated as “night birds” from the Haida language, *Synthliboramphus antiquus*, a COSEWIC listed species) and two species of storm-petrels (*Oceanodroma furcata* and *O. Leucorhoa*). This project comprises three components: pre- and post- eradication monitoring (of both key ecosystem indicators and impacts to non-target species), Phase 1 eradication (~100 ha using bait stations), and Phase 2 eradication (750 ha using bait broadcast techniques). The project is a collaboration between Gwaii Haanas, Island Conservation, Coastal Conservation, Simon Fraser University, and the Luckenbach Council. We present here a summary of pre-eradication monitoring, and Phase 1 eradication, completed in 2011. Modified eradication techniques dramatically reduced non-target species risk while still achieving the desired result. We see great potential for expansion of such restoration work both across lands managed Parks Canada Agency, and in other high value conservation areas in Canada. To harness this opportunity, increasing international participation and financing of such projects is required.

#### PATTERNS IN NESTING SUCCESS OF CASPIAN TERNS ACROSS WESTERN NORTH AMERICA IN 2011



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The world's largest colony of Caspian Terns (*Hydroprogne caspia*), on East Sand Island near Astoria, Oregon, experienced complete nesting failure for the first time during the 2011 breeding season. The proximate cause of colony failure was intense disturbance by Bald Eagles (*Haliaeetus leucocephalus*) and associated nest predation by Western/Glaucous-winged Gulls (*Larus occidentalis* x *L. glaucescens*). The colony may now have attracted an insurmountable level of predation due to its large size (nearly 10,000 pairs) and consistent presence over the last 13 years. Natural history traits of this species, particularly low nest site fidelity and sporadic utilization of historical colony sites, seem to corroborate this top-down explanation of colony abandonment. However, a survey of Caspian Tern nesting success across western North America suggests an alternative hypothesis. All breeding attempts by Caspian Terns in coastal Washington also failed, and few initiated nesting in the San Francisco Bay area. Colonies in interior Washington were normal in size and productivity; however, higher elevation sites in interior Oregon and California experienced late and limited nest initiation and generally poor productivity. Because reproductive success was very low for coastal and higher elevation inland colonies over a large geographic area, we hypothesize that climate conditions in early 2011 were poor for Caspian Terns from northern California to Washington, resulting in low food availability and limited reproductive investment. This regional pattern in nesting success suggests that climate-mediated prey availability may have been a major contributing factor in the nesting failure of the East Sand Island Caspian Tern colony.

#### ACOUSTIC ACTIVITY AS AN INDEX OF RELATIVE ABUNDANCE AT SEABIRD COLONIES: A LOW-COST AND SCALABLE TOOL FOR MEASURING CONSERVATION OUTCOMES.

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Seabirds are ecologically important and face conservation threats in marine and terrestrial ecosystems. Monitoring programs to assess seabird populations and measure the success of conservation actions are hampered by the remoteness of many seabird colonies and the global scale of the threats. Innovative technology may now make it possible to remotely monitor seabird colonies at the larger spatial scales necessary for conservation. Automated acoustic sensors offer a low-cost, low-impact method for monitoring seabirds. Here we tested the efficacy of acoustic sensors to measure relative seabird abundance at colonies. Sensors recorded ambient noise at Forster's Tern (*Sterna forsteri*) breeding colonies in San Francisco Bay for two breeding seasons. We used an automated method (spectrogram cross-correlation) to detect and count tern vocalizations from recordings. We calculated mean calling rates at different time scales and compared these to active nest counts at colonies. Our results show that acoustic activity was a strong index of colony size within years (2009  $r^2=0.84$ ,  $n=5$ ; 2010  $r^2=0.59$ ,  $n=7$ ) and a powerful index of change in colony size between years ( $r^2=0.92$ ,  $n=5$ ). We also estimated the predictive

power of an acoustic activity index to detect population changes. Quantifying the relationship between acoustic activity and relative abundance is a fundamental step in designing effective acoustic monitoring programs for seabirds and other vocalizing wildlife. These tools present low-cost, scalable and comparable tools for measuring population trends and responses to conservation actions.

## MONITORING MARBLED MURRELETS WITH ACOUSTIC SENSORS – COMPARING AUTOMATED DETECTIONS WITH HUMAN AUDIO-VISUAL MONITORING

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Acoustic sensors provide a potentially low-cost alternative for monitoring Marbled Murrelets in remote areas over long survey periods. To assess the efficacy of this approach we compared monitoring methodologies at 7 sites in the Santa Cruz Mountains (CA) in 2010 – audio-visual surveys by trained observers and acoustic monitoring with automated acoustic sensors. We compared audio/visual detections of murrelets by trained observers with acoustic detections of murrelets, identified from sensor recordings using automated spectrogram cross-correlation. Mean automated acoustic detections were highly correlated with mean rates of human a/v detections across sites ( $r^2=.97$   $n=7$ ,  $p<.05$ ). Acoustic detections were positively correlated with a/v detections on the same morning ( $r^2=.42$ ,  $p<.05$ ), and highly correlated with a 5 day average of acoustic activity centered on the morning of a/v survey ( $r^2=.61$ ,  $p<.05$ ). Despite lower detection rates (18% of human a/v detects), acoustic sensors had greater power to detect murrelets at low-abundance sites due to sampling a greater number of mornings (518 vs. 31 mornings). Results suggest that automated acoustic sensors could provide a scalable, low-cost tool for monitoring murrelets at inland sites. Specifically, sensors could be used to increase the spatial and temporal scale of surveys and could be used to help direct human surveys to monitor for site occupancy. It would be valuable to compare metrics of acoustic activity at known breeding and non-breeding sites to determine if acoustic indices and activity patterns could also be used to identify occupied forest stands, something that is currently delineated primarily with visual cues.

## MONTROSE SETTLEMENTS RESTORATION PROGRAM-RESTORING SEABIRDS ON THE CHANNEL ISLANDS

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The Montrose Settlements Restoration Program (MSRP) released a draft Phase 2 Restoration Plan in October 2011. The draft plan summarizes restoration work that has been completed from the Phase 1 Restoration Plan and proposes projects for the next phase. The plan focuses on restoring natural resources that were affected by DDT and PCB contamination in the Southern California Bight. The MSRP was developed in 2001 to oversee restoration of resources harmed by DDT and PCBs. The six federal and state agencies that administer this program work to implement restoration projects and monitor recovery of resources that were harmed. MSRP is celebrating ten years of restoration planning and implementation. One of the main focuses of the Phase 1 Restoration Plan was the restoration of seabird habitat on several Channel Islands including Santa Barbara, Santa Cruz, and San Nicolas Islands. The discovery of nesting seabirds in recently restored habitat on Santa Barbara Island is a major indicator of the success of these projects. Phase 2 will continue the seabird habitat restoration efforts on Santa Barbara Island and Santa Cruz Island. In addition, habitat restoration efforts will begin in Phase 2 for the Ashy Storm-Petrel and other seabirds on Anacapa Island.

## PRODUCTIVITY, DIETS AND PLASMA CORTICOSTERONE LEVELS OF GLAUCOUS-WINGED GULLS, TUFTED PUFFINS AND BLACK-LEGGED KITTIWAKES IN THE NEAR-SHORE OF KODIAK ISLAND, ALASKA

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It is well established that seabird diets, patterns of nest attendance and productivity are sensitive to changes in marine conditions; thus, results of monitoring of the biology of seabirds has yielded corroborating evidence for changing marine foraging conditions. Within the past two decades, biologists have increasingly utilized plasma glucocorticoid levels of seabirds in combination with more traditional indicators of marine conditions. From 2001-2005, we monitored productivity or fledging success, timing of reproduction, growth rates, and diets of three seabird species that breed in Chiniak Bay, Kodiak Island, Alaska: a surface feeding larid (*Rissa tridactyla*), a near-shore foraging larid (*Larus glaucescens*) and a diving alcid (*Fratercula cirrhata*). In addition, we obtained blood samples for analysis of plasma corticosterone levels. Diets did not appreciably differ either among species or over years. Productivity of both Black-legged Kittiwakes and Glaucous-winged Gulls decreased across years with relatively high levels in 2001 and 2002 and very low levels in 2004 and 2005. In contrast, Tufted Puffins exhibited high levels of reproductive success throughout the study. Plasma corticosterone levels of both Black-legged Kittiwakes and Glaucous-winged Gulls were inversely related to reproductive performance. Overall, our results indicate that warmer and less saline ocean conditions negatively impact reproduction by Black-legged Kittiwakes and Glaucous-winged Gulls but neither positively nor negatively affect reproductive performance of Tufted Puffins. The disparity between species likely reflects differences in the spatial extent of foraging, the timing of peak energy demands, or the threshold biomass of forage fishes required for successful reproduction.

## ASSESSING RISKS FROM LOSS OF NESTING HABITAT FOR MARBLED MURRELETS IN REGIONAL LAND-USE DECISIONS ON THE BRITISH COLUMBIA COAST

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Identifying risks to populations from habitat reduction is a common problem in conservation and resource management. As part of major land-use decisions in the central and northern coasts of British Columbia, Ecosystem Based Management (EBM) criteria are to be applied. The decisions specify that land management should not create high levels of risk for focal species, which include the Marbled Murrelet (*Brachyramphus marmoratus*). Risk curves were developed for this and other focal species to identify thresholds for Low Risk (habitat changes do not exceed natural variation) and High Risk (habitat loss causes serious ecological degradation and unsustainable populations) relative to habitat areas and quality. We describe the process of developing a habitat risk curve for the murrelet using: empirical data (range of natural variation in old-growth forest areas; relationships between murrelet numbers and habitat area; probability of nesting relative to habitat quality); results of population viability models developed for this region; and expert-based assumptions. High and Low risk thresholds were estimated to be at 33% and 88% retention of historical habitat area, respectively, considering likely nesting habitat as the three highest ranks in a six-rank habitat-quality system. Our moderate risk scenario (66% retention of historical habitat) is consistent with theoretical viability thresholds for deleterious population and genetic effects and is close to the retention recommended by the Canadian Marbled Murrelet Recovery Team for these regions. This exercise identified uncertainties in data, knowledge and future management decisions, thereby highlighting major information gaps for managing murrelets in these regions.

## PATTERNS IN NATURAL SEABIRD RE-COLONIZATION AND RECOVERY AFTER PREDATOR REMOVAL

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Human-introduced predators have devastated populations of island fauna, notably seabirds. To date, over 750 islands have been cleared of introduced predators internationally. Predator eradication has not only alleviated pressure on threatened seabird species, it has provided the opportunity to investigate the dynamics of seabird population recovery. However, seabirds have low productivity, late ages at first breeding, and strong philopatry, so natural recovery can be very slow or may not happen at all. Long-term

seabird studies after eradication are thus rare. In New Zealand, eradication projects span the last 40 years, providing a range of timelines to study seabird response. We reviewed and analyzed post-eradication seabird response using all available abundance estimates, demographic rates, and presence-absence information from offshore islands around New Zealand. By comparing these data before and after eradication, we attempted to predict which species and location characteristics result in higher probabilities of re-colonization or positive population growth. Of 93 islands cleared of predators, 14% showed seabird re-colonization, and 16% had an increase in seabird population size. We also applied our model to global post-eradication seabird data. Preliminary results indicate that seabirds respond more frequently on islands with large nearby populations and species with earlier ages at first breeding respond more rapidly. The management implications of this review include the possibility of informing future eradication programs and optimal locations for post-eradication monitoring.

#### DRAMA IN NEST SITE #5: UP CLOSE AND PERSONAL WITH THE XANTUS'S MURRELET

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The purpose of this study was to assess the nesting behavior of Xantus's Murrelets (*Synthliboramphus hypoleucus*). Current efforts to enhance the population of this rare seabird include nest site restoration through the removal of invasive plant species and the planting of native plants on Santa Barbara Island, Channel Islands National Park, CA where twenty percent of the population of Xantus's murrelets breed. Invasive plant species inhibit the burrowing behavior of Xantus's murrelets. We observed video footage from one nest equipped with a camera in 2010. We viewed, categorized and recorded all the behaviors and events we observed during the entire breeding season (from prospecting, incubation, and chick rearing until fledging). We observed two pairs of Xantus's murrelets fighting for the same nest site. A total of three eggs were laid in the nest but due to violent scuffles between the two pairs, two eggs were compromised and did not hatch. Only one chick fledged successfully. During the fights, members of the second pair were forced to leave. Members of the first pair incubated all three eggs. Fighting occurred at least once every two days. We found that the birds were very active in the early evening and morning hours; the frequency of egg turning was greatest during those times. These seabirds are known for long periods of 'egg neglect'. We observed a nine-day non-incubation interval. Our results indicate that competition for nest sites may be high and that nest site restoration may be an effective way to alleviate this problem.

#### COMPLEX FOODWEB DYNAMICS OF MARINE BIRD COMMUNITIES OF THE HIGH AND LOW ARCTIC

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Understanding the complex dynamics of environmental change in northern latitudes is of paramount importance today, given documented rapid shifts in sea ice, plant phenology, temperatures, deglaciation, and habitat fidelity. This knowledge is particularly critical for Arctic avian communities, which are integral components that maintain biological teleconnections between the mid- and northern latitudes. Furthermore, polar birds are fundamental to Native subsistence lifestyles and serve as foci for conservation and ecological research. This project has several objectives: to quantify the network dynamics of marine bird foodwebs, to understand the nature of their recent and past changes, and determine how High and Low Arctic patterns may be related to climate change. Our ultimate goal is to predict these patterns using direct and proxy measures of change. We will apply and extend the quantitative approach we used previously for the far western Aleutian Islands—stable isotopes, complex networks, multivariate logistic and loglinear analysis—for comparable datasets from lower and higher latitudes (eg., Subarctic Aleutians, High Arctic Greenland). Our preliminary results indicate that community-wide spatial and temporal dynamics of distribution and abundance can be successfully elucidated. We will test this approach on new regional data and initiate development of predictive models using dynamic network theory.

#### FLIGHT ALTITUDES OF NEWELL'S SHEARWATER (*PUFFINUS AURICULARIS NEWELLII*) AND HAWAIIAN PETREL (*PTERODROMA SANDWICHENSIS*) ON THE ISLAND OF KAUA'I AND RELATIVE RISK OF COLLISION WITH HUMAN-MADE STRUCTURES

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During the breeding season, Newell's Shearwaters and Hawaiian Petrels travel in low-light conditions between inland nest sites and open-sea foraging locations, resulting in occasional collisions with human-made structures. To understand the flight behavior that lead to this mortality, we used marine radars to measure flight altitudes of these species at four coastal locations on Kaua'i. Over 26 survey days, we measured 3,413 petrel/shearwater altitudes with the vertical radar. The mean flight altitude (meters above ground level [agl]) of petrel/shearwater targets measured by radar was  $250.4 \pm 2.2$  m. Fifty percent of Newell's Shearwater and Hawaiian Petrel radar targets occurred between 225 and 945 m agl, and 25% of them occurred less than 160 m agl. Across most sites, fall flight altitudes were significantly lower than those in the spring. There was a positive relationship between flight altitude and distance from the ocean. Vertical radar heights for all sites combined were fit to a gamma distribution curve to determine the proportion of low-flying birds that may be at risk of collision by future developments on the Hawaiian Islands. By using the maximal height expected for a wind turbine, communication tower, and utility-transmission structure, we estimate that 16.3%, 6.2% and 0.1% of these birds, respectively, would be at risk of interaction with these structures on a given night at the sites we studied. Risk increases for



transiting petrels and shearwaters near the coast and during the fall fledging season, although collisions with structures are possible throughout their breeding season and along any flight corridor.

#### THERE GOES THE NEIGHBORHOOD: SITE FIDELITY AND GROUP ADHERENCE AT A CASPIAN TERN (*HYDROPROGNE CASPIA*) COLONY FACING HABITAT REDUCTION AND INCREASED PREDATION

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Nest site fidelity is presumed to be an adaptive trait evolved to enhance reproductive success. In colonially-nesting seabirds the proclivity to return to a previous nest site helps reunite partners, diminish environmental unknowns, and increase familiarity with neighboring pairs. Nest site fidelity can be a liability if birds remain faithful to a location where habitat suitability declines, or where predators target nesting birds as a food resource. The Caspian Tern (*Hydroprogne caspia*) colony on East Sand Island (ESI), Columbia River estuary, Oregon is the largest in the world, supporting ca. 9,500 breeding pairs. During the 2011 breeding season, the ESI colony experienced two potentially major changes: a managed 35% reduction in available nesting habitat and the advent of on-colony predation of breeding adults by Bald Eagles (*Haliaeetus leucocephalus*). Eagle disturbance, coupled with intense egg predation by Glaucous-winged/Western gulls, resulted in an unprecedented total colony failure. Using a Leica TPS1200+ rangefinder, I pinpointed nest sites of banded birds in 2010 and 2011 and, combined with GPS mapping, quantified inter-annual nest site fidelity and movements in response to reduced habitat availability. I was also able to look at colony fidelity patterns of cohorts banded in six different years on ESI. During two breeding seasons individual terns used nest locations in close proximity, and retained individuals as neighbors. Additionally, terns demonstrated three distinct responses to colony failure: serial re-nesting attempts on ESI, re-nesting attempts at alternative colonies in coastal Washington, and abandonment of nesting efforts with increased use of alternative roost sites.

#### WORKING THE NIGHT SHIFT: A FINE-SCALE STUDY OF THE DIURNAL/NOCTURNAL FORAGING BEHAVIOR OF TWO HAWAIIAN ALBATROSSES

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Albatrosses use two primary foraging strategies: 1) search-while-flying and 2) sit-and-wait while on the water. Sit-and-wait foraging occurs at small spatial scales, is difficult to detect, and is often overlooked. Nevertheless, these two strategies are likely employed separately when searching for different prey types. We tracked the at-sea movements of Laysan (*Phoebastria immutabilis*) and black-footed (*P. nigripes*) albatrosses using GPS loggers during the chick-brooding periods of 2005/2009/2010 from Tern Island, Hawaii. The high-resolution data allowed us to compare fine-scale foraging behavior, including sit-and-wait foraging, across the diurnal cycle. First-passage time analysis revealed that albatrosses foraged at



two scales, a primary scale of 5-10km and a secondary scale of 30km. Both species spent 70% of their trip in flight and 30% on the water, but Laysan albatrosses spent significantly more time on the water at night (34.2%) than during the day (14.3%) while black-footed albatrosses spent an equal amount of time on the water between night (34.2%) and day (36.4%). Landing rates of black-footed albatrosses were similar between night (30.78/hr) and day (37.34/hr), while that of Laysan albatrosses decreased from 42.43/hr during the day to 28.43/hr at night. Behavior indicative of both foraging strategies occurred both night and day for all birds. Both species had a significant increase in flight sinuosity and decrease in flight speeds at night, suggesting a switch to higher nocturnal in-flight searching intensity. High precision data allowed us to identify previously overlooked sit-and-wait foraging and nocturnal/diurnal behavior that have important implications for the foraging ecology of albatrosses.

## CONSERVATION AND RESTORATION OF ISLANDS IN THE SOUTHERN OCEAN

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The islands of the Southern Ocean are among the World's most pristine habitats, supporting largely intact ecosystems. They support significant seabird populations, many endemic, some globally threatened. Nearly all have no permanent human populations and land-use activities are restricted. Most are legally protected as nature reserves with management plans and several are either World Heritage Sites or Ramsar Wetlands of International Importance. However, despite their natural attributes and isolation far from the main centres of human occurrence and activity, Southern Ocean islands and their biota face serious threats, including from climate change and from introduced animals and plants. Threats from commercial fisheries are affecting some of the most charismatic members of their biota, the large procellariiform seabirds. Most Southern Ocean islands are well studied, including their avifauna. Recent and current research on and around the islands is largely directed at gaining information of value towards conservation. In addition, and increasingly in recent years, actions are being taken, and being planned, to contribute towards the restoration of the islands' ecosystems and biota. Such activities include eradication of introduced species and improved biosecurity to reduce the risks of new invasions on land, and efforts to reduce avian bycatch in both longline and trawl fisheries at sea. In contrast climate-change effects cannot be ameliorated directly, and so are unlikely to be addressed within a human time-scale. As a consequence some local extinctions may occur. Only a few countries possess Southern Ocean islands and there remains scope for increased international collaboration in their management.

## SEABIRD VULNERABILITY TO CLIMATE CHANGE IMPACTS IN THE NORTHWESTERN HAWAIIAN ISLANDS

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Throughout the first half of the 1900s seabird populations in the Northwestern Hawaiian Islands (NWHI) suffered from hunting, persecution, and introduced predators. In the second half of the century, there has been an extensive effort to improve the conditions for these and other NWHI species by decreasing human disturbance, eradicating non-native predators and plants, and removing hazards. As part of Papahānaumokuākea Marine National Monument, the NWHI provide nesting habitat for a large assemblage of tropical seabirds. The small low-lying islands of the NWHI are, however, especially vulnerable to the effects of climate change such as sea-level rise (SLR), severe storms, and wash-over events. SLR could lead to a reduction of island size, shrinking already limited habitat for the 14 million seabirds that nest in this region. We developed a climate change vulnerability index for NWHI nesting seabirds. We chose attributes of nesting behavior (e.g., philopatry), seasonal overlap with winter storms, flexibility in nesting habitat, and sensitivity to disturbance to be included in the index. Species differed greatly in their vulnerability to climate change impacts.

#### TECHNICAL INNOVATIONS FOR THE CENSUS AND MONITORING OF NON-COLONIAL SEABIRDS (*BRACHYRAMPHUS* MURRELETS) IN ALASKA

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The Marbled Murrelet (*Brachyramphus marmoratus*) and Kittlitz's Murrelet (*B. brevirostris*) are cryptic, solitary-nesting seabirds that breed sympatrically in parts of Alaska. Both species have apparently declined, but efforts to monitor populations are hindered by the difficulty in locating nests and low power to detect trends in at-sea vessel surveys. We report new methods for censusing and monitoring *Brachyramphus* murrelets in Alaska using radar and acoustic sensing, and compare results from these methods with concurrent at-sea counts in waters adjacent to nesting habitat. High-frequency marine radar is a standard tool for monitoring populations of marbled murrelets in forested watersheds south of Alaska, but requires modification for Alaskan conditions (two species with similar radar images; extended twilight flight activity; stronger winds). We tested radar for tracking murrelets flying to and from nest sites on Kodiak Island in 2010 and 2011 (2100 and 6800 detections, respectively), and in 2011 used a combination of radar and autonomous acoustic recording devices (981 hours of recordings). We assess the value of acoustic data (wingbeats and vocalizations) from flight paths and nesting habitat to determine species identity and complement radar counts. Marbled Murrelets made up >99% of murrelets counted at sea in 2011, and concurrent radar counts confirmed that this species is primarily ground-nesting on Kodiak Island. The highest counts occurred in watersheds providing high-elevation, treeless habitat. The combined methods provide insights into murrelet behavior, seasonal attendance and habitat associations, and contribute to refining protocols for population censusing and monitoring.

#### GLOBAL CONSERVATION OF THREATENED SEABIRD BREEDING ISLANDS

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Seabirds play important functional roles in marine and terrestrial ecosystems, yet are the most threatened group of marine animals, with 28% of species at some risk of extinction. The most significant threats to seabirds occur on their breeding islands where effective conservation actions are feasible. To guide island-based seabird conservation actions, we developed a database of current breeding islands for the 97 species of seabirds listed by the IUCN as threatened (Critically Endangered, Endangered and Vulnerable). A total of 907 threatened populations breed on 653 islands. Procellariids (shearwaters & petrels) comprise the largest number of threatened species (36 of 97 species; 37%) and they breed as 151 populations on 142 islands. Diomeduids (albatrosses) are proportionally the most highly threatened group (17 of 22 species; 77%) and threatened species breed as 185 populations on 155 islands. The metapopulation structure of threatened seabird families influences the relative cost of island-based conservation as well as the relative importance of individual islands. On average, threatened Procellariids breed on 4.2 islands species<sup>-1</sup> while threatened Diomeduids breed on 10.9 islands species<sup>-1</sup>. Globally, colony-based threats can be mitigated for at least one population of all threatened seabirds through conservation efforts on only 55 islands and for all Critically Endangered seabird populations by action on only 49 islands. Because conservation action on breeding seabird islands is logistically and economically feasible, colony-based protection of threatened seabirds is a unique conservation opportunity.

#### TRANS-EQUATORIAL MIGRATION OF SABINE'S GULLS (*XEMA SABINI*) FROM A BREEDING SITE IN THE CENTRAL CANADIAN HIGH ARCTIC

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The Sabine's Gull (*Xema sabini*) is the only known Arctic gull to undertake a trans-equatorial migration, flying more than 13,000 km from breeding grounds in the circumpolar arctic to wintering areas in the Southern Hemisphere. Sabine's Gulls winter in two distinct pelagic zones; the Humboldt Current off the western coast of South America and the Benguela Current off the southwestern coast of Africa. We used geolocators (Lotek LAT2900) to track the migration of Sabine's Gulls from a breeding site in the Central Canadian High Arctic. Preliminary results show that Sabine's Gulls breeding on Nasaruaalik Island in Nunavut migrate westward to Alaska in the fall, following the Pacific Coast south to the rich cold waters of the Humboldt Current. In 2011, we recovered 19 of 23 geolocators deployed in 2010 (83%), and re-sighted 22 of the 23 tagged birds (96%). This suggests that adult survival is extremely high in this population of Sabine's Gulls, in contrast to far lower returns from Atlantic birds tagged in Northeastern Greenland, which were shown to winter within the Benguela Current by Stenhouse et al. (2011). To what extent this discrepancy can be attributed to at-sea mortality is not yet clear.

## ISSUES OF IMPORTANCE FOR A MONITORING PROGRAM FOR KITTLITZ'S MURRELETS IN ALASKA

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To date, so many methods for monitoring Kittlitz's Murrelet (*Brachyramphus brevirostris*) populations in Alaska have been used that trend comparisons over time, both within and among sites, have become almost meaningless. Hence, there is a need to develop a consistent and rigorous methodology for monitoring Kittlitz's Murrelet populations at sea. Here, I discuss several important aspects of a study design that should be considered and incorporated into such a monitoring program. These issues include focusing the sampling on the metric of interest; developing an appropriate and statistically strong study design; using line-transect methodology; incorporating flying birds into population estimation with “snapshot” sampling; incorporating the nearshore–offshore density gradient into sampling design; minimizing the number of unidentified birds; proper methods for incorporating unidentified birds into population estimates; developing a consistent seasonal sampling date; conducting single-species surveys for *Brachyramphus* murrelets; and developing regional sampling methodologies for different parts of Alaska.

## ORNITHOLOGICAL RADAR SURVEYING FOR HAWAIIAN PETRELS AND NEWELL'S SHEARWATERS IN WAIPI'O AND POLOLŪ VALLEYS, KOHALA MOUNTAIN, HAWAI'I

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We determined abundance and coastal movement patterns of federally-listed endangered Hawaiian Petrels (*Pterodroma sandwichensis*) and threatened Newell's Shearwaters (*Puffinus newelli*) in Waipi'o and Pololū Valleys, Kohala Mountain, Hawai'i Island, 20-29 June 2011 using ornithological radar and visual surveying methods. At each site, we confirmed species presence, established a standardized monitoring protocol, estimated population during June (incubation), and described local movement patterns. Low numbers of seabird targets were recorded overall ( $n=108$ ). Timing of radar target activity agrees with pattern of arrival after sunset observed for each species on Kaua'i, indicating that timing of arrival can be used at these sites as a general measure for calibrating radar targets to species. Visual sightings confirmed the presence of both species at Waipi'o, and only Hawaiian Petrels at Pololū, though timing of radar target activity indicates Newell's Shearwaters are present as well. A 76% decline in target activity occurred at Waipi'o since 2001, with 6.3 targets  $\text{hr}^{-1}$  recorded, about one-fourth of the expected target activity rate given the documented pattern for these species during June on Kaua'i. Differences in flight direction recorded among sites, and among sessions at each site, indicated radar could be used in combination with on-the-ground efforts like auditory surveying, to aid colony searches in the Kohala Mountain region. Importantly, further studies are needed for improving trend analysis, particularly at Waipi'o.

## SHIFTING PREY IN A MELTING ARCTIC: BREEDING SEABIRDS ADAPT TO THE LOSS OF SUMMER ICE

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Reduced sea ice extent and increased ocean temperatures were associated with decadal-scale prey switching at a northern Alaska Black Guillemot (*Cepphus grylle*) colony. From 1975 to 2002 guillemots on Cooper Island provisioned nestlings almost exclusively with Arctic Cod (*Boreogadus saida*) but starting in 2003 the frequency of sculpin (*Myoxocephalus* spp.) in the diet increased, correlated with increases in distance to sea ice and sea surface temperatures. Sculpin now are the primary prey for most of the 20 July – 10 September nestling period. Until 2011, the appearance of sculpin in the chicks' diet was associated with colony-wide decreases in nestling growth and increased nestling death. In 2011, however, over half of the breeding pairs maintained high nestling growth when prey switched from Arctic Cod to sculpin in early August. Nesting failures associated with a switch to sculpin in earlier years may have been due to low sculpin abundance or availability caused by low water temperatures. In 2011, after the switch to sculpin, growth rates of nestlings decreased during a period of decreased water temperature. The ability of some, but not all, guillemot pairs to maintain nestling growth after the prey switch in 2011 apparently reflects individual variation in adaptability to short-term changes in prey type. The high breeding success in 2011 demonstrates that Black Guillemots can persist in arctic Alaska despite the loss of summer ice by switching from ice-associated prey to benthic prey. Another prey shift could occur with the anticipated range expansion of subarctic fish into the Beaufort Sea.

#### OCEANOGRAPHY FOR THE ORNITHOLOGIST: CLIMATE CHANGE AND HAWAIIAN SEABIRDS

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The climate of the Pacific region is always changing but only recently has it experienced directional, anthropogenic change. Robust results from virtually all global climate models include: (1) warming of the atmosphere and the oceans leading to stratification changes, (2) pole-ward shifts of the westerly winds at mid latitudes, and (3) sea level rise. Due to the chemical interactions of increasing atmospheric CO<sub>2</sub> with seawater, the pH of the oceans is declining (ocean acidification). The Hawaiian Islands are home to 30M seabirds representing 22 breeding species that rely heavily on the marine resources of the entire North Pacific. Reviewing current understanding of the meteorology and oceanography of the North Pacific, we will discuss factors that may affect seabirds, such as changes in sea and air temperature, rainfall, sea level rise and inundation, changes in storm frequency and intensity, changes in prey distribution and abundance, and ocean acidification. Many common and well-known management actions may ameliorate the symptoms for seabird populations but will not remove the causes. We examine the need to better distinguish the effects of natural from anthropogenic change and propose a hypothesis-driven research agenda focused on factors that appear to rank high in certainty and severity of impacts on Hawaiian seabirds. This may allow us to refine and better focus management efforts.

## AGE-RELATED VARIATION IN SURVIVAL AND MOVEMENT RATES OF THE ADÉLIE PENGUIN IN RESPONSE TO COLONY SIZE AND BREEDING STATUS.

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Survival and movement probabilities of adult breeding Adélie penguins (*Pygoscelis adeliae*) vary between colonies of different sizes and among years or in relation to environmental disturbance. However, key demographic parameters are still needed for future population modeling; specifically, age-related variation in survival, and rates of natal philopatry. Age-at-first-reproduction for this species is reported to be highly variable (3-7 years) and the environmental factors that may affect this parameter are poorly understood. Here we present age-related survival and movement rates during 13 years of varying environmental conditions for Adélie penguins from a 3-colony system in the Ross Sea. We observed differences in survival and philopatry rates in relation to breeding status, age and colony size. Survival was lowest the first 2 years after fledging (subadults), but then varied after age 3 in relation to breeding status, with the highest survival observed for non-breeders, followed by pre-breeders, and the lowest rates observed for breeders. In addition, survival rates are lower at our smallest colony compared to both of our two larger colonies, consistent with a previous analysis of adult, breeding birds of unknown age in this meta-population. The probability of transitioning from a pre-breeder to a breeder was highest for age classes 5-8, and age-at-first breeding did not differ by colony. We continue to explore the complex age- and breeding state demographics of this species in relation to environmental variation, as this will be the key to understanding how resilient this species may or may not be to climate change.

## OVERVIEW OF RECOVERY ACTIONS FOR THE HAWAIIAN PETREL (*PTERODROMA SANDWICHENSIS*)

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The endangered Hawaiian Petrel has recently benefitted from peer reviewed input on actions needed to effect recovery from a multi-lateral group of experts in the biology and conservation of montane petrels



and shearwaters. This has resulted in the Newell's Shearwater and Hawaiian Petrel: Five-year Action Plan (2011); it proposes a unified approach to guide conservation management and research needed to maintain population-based stability and increase nesting colonies of the Hawaiian Petrel. Discussed here is the progress on the five goals listing the actions required for multi-island implementation of the action plan for Hawaiian Petrel, addressing the often unique adjustments dictated by the differing life biology of known nesting colonies on the different islands in the petrels current distribution. These goals are: determining and maintaining current petrel distribution; expansion and re-establishment of extinguished distribution; implementation of standardized monitoring at island and colony scale; elucidation of at sea threats; and implementation of multi- and interagency structure and plans for long-term commitments to Hawaiian Petrel recovery. The progress achieved across the islands on threat abatement and existing colony management, colony monitoring techniques, understanding of issues for petrels at sea, and some early results for searches, delineation, and monitoring of historic, existing, and new colonies, are discussed. Mitigation for anthropogenic threats from infrastructure has recently resulted in changes in Save our Seabirds (SOS) programs, new proposals of both conventional and predator-proof fencing of habitat, and new potentially population bolstering projects involving social attraction and translocation work.

## NATIVE SEABIRD REHABILITATION IN THE PACIFIC ISLANDS

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The Pacific Islands are home to twenty-two indigenous and endemic seabird species, including the endangered Short-tailed Albatross (*Phoebastria albatrus*), the endangered Hawaiian Petrel (*Pterodroma sandwichensis*) and the threatened Newell's Shearwater (*Puffinus auricularis newelli*). Combined pressures of food availability, rising ocean temperatures, breeding habitat depletion, human-wildlife conflicts, oil contamination, and predation by alien species have negatively impacted both the ecology and population success of seabirds.

In partnership with larger conservation efforts, professional wildlife rehabilitation of native seabirds plays a vital role in mitigating these effects. Endangered species, and in particular those with low reproductive rates, can benefit greatly from the rehabilitation of individual animals. Wildlife rehabilitation integrates veterinary medicine, biology, and ecology to establish specialized captive care techniques for wildlife. Veterinary nursing, wound and disease management, nutrition, behavior, husbandry and post-release success are basic components in rehabilitation efforts. Professional wildlife rehabilitation uses internationally accepted standards of care and formally collaborates on research projects to assist with seabird response and mitigation programs.

## THE KAUAI SEABIRD HABITAT CONSERVATION PROGRAM – A LONG-TERM APPROACH FOR MITIGATING EFFECTS OF SEABIRD LIGHT ATTRACTION AND UTILITY COLLISION

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The Kauai Seabird Habitat Conservation Program is being developed by the Division of Forestry and Wildlife in coordination with the U.S. Fish and Wildlife Service to address island-wide impacts to Newell's shearwater (*Puffinus newelli*, threatened) and Hawaiian petrel (*Pterodroma sandwichensis*, endangered) due to artificial light attraction and utility line collision. These impacts are considered "incidental take" under federal and state endangered species laws and are illegal without federal and state permits. A Habitat Conservation Plan (HCP) such as the KSHCP is a solution for non-federal entities that authorizes activities that cause incidental take and specifies implementation of mitigation measures that reduce and offset impacts. The KSHCP process illustrates the challenges of creating an effective regulatory solution that also succeeds in supporting species recovery priorities. The draft KSHCP is a framework HCP that would address island wide take levels and accommodate numerous participants over an anticipated 30 year period. The KSHCP sets forth requirements for participants to minimize existing and future impacts of lighting and utilities to the maximum extent practicable. Impacts that cannot be avoided must be offset through compensatory mitigation strategies. These strategies are being designed to support species recovery priorities and provide net conservation benefit to the species. KSHCP minimization and mitigation strategies must be managed adaptively to adjust management in response to new scientific data. Once approved, the KSHCP can provide a significant long-term funding mechanism to mitigate incidental take and contribute to the recovery of endangered seabirds on Kauai.

## THE ECOLOGY OF THE INVASIVE ANT SPECIES *ANOPLOLEPIS GRACILIPES* AND ITS IMPACT ON BREEDING SEABIRDS AT JOHNSTON ATOLL

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In January 2010 an infestation of yellow crazy ants (*Anoplolepis gracilipes*) was discovered at Johnston Atoll National Wildlife Refuge, one of the most isolated seabird colonies in the world. The introduction of these ants threatens the only available breeding habitat for 14 species of seabirds found in 750,000 square miles of ocean. Yellow crazy ants form supercolonies that reach high densities and have the ability to spread at rates of 0.1 to 3.0m per day. Formic acid is sprayed as a defensive mechanism from their abdomen, which severely irritates and can even blind seabirds. This leads to nest abandonment and possible chick mortality. To date these ants have displaced virtually all ground nesting seabirds in approximately 23% of the 640 acre island. To address these threats Johnston has become a focus of efforts to expand the understanding of yellow crazy ant ecology and its impacts, while developing effective eradication techniques. A variety of baits, carriers, and application techniques are being investigated using experimental treatment plots, palatability trials, and bioassays. Commercial baits tried thus far have been shown ineffective on Johnston's crazy ant population. Adaptive management strategies are being employed to tailor bait recipes in the field in response to current ant colony demands. Monitoring of impacts on seabirds in the infestation is currently ongoing. Continued efforts bring us ever closer to a successful eradication; the effects of which would not only benefit the unique habitat Johnston offers Central Pacific seabirds, but will provide invaluable lessons for ant eradication efforts worldwide.

## SEABIRD ASSOCIATIONS WITH THE COLUMBIA RIVER PLUME OFF OREGON AND WASHINGTON DETERMINED USING AIRBORNE HYPERSPECTRAL RADIOMETRY

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Marine spatial planning, including the designation of important marine bird areas and potential site selection for offshore energy development, requires the quantification and description of species-specific patterns in distribution with measurable habitat features. Such relationships can aid predictive models to refine population estimates at sea and delineate important habitats outside surveyed areas. In the northern California Current System, seasonal upwelling and the Columbia River plume create oceanographic structure. This structure includes enhanced phytoplankton growth and formation of physical frontal boundaries that can aggregate prey near the surface, thereby increasing availability for top-level predators. To relate patterns of seabird abundance to physical and biological characteristics of ocean habitats, we conducted aerial seabird surveys during January and June 2011 along strip-transects spanning continental shelf and slope waters off Washington and Oregon. We installed a hyperspectral radiometer and a radiation pyrometer on board the aircraft to collect simultaneous remotely-sensed reflectance and sea surface temperature, respectively. We used along-transect gradients in three ocean habitat variables (sea surface temperature, synthetic salinity, and fluorescence line height) to 1) identify frontal features associated with, and independent of, the Columbia River plume and 2) examine relationships between these features and the distribution and abundance of common marine birds. In the past, aerial seabird surveys have relied on satellite-derived products of ocean optical properties that are coarse in scale or temporally-averaged to produce better spatial coverage. Herein, we couple the ability of aerial surveys to obtain rapid coverage of large geographic areas with high-resolution, instantaneous oceanographic information.

#### SEABIRD RESTORATION PROJECT ON ASUNCIÓN AND SAN ROQUE ISLANDS: EXPERIENCES AND INPUTS FOR A WIDE REGIONAL STRATEGY.

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A seabird social attraction project is taking place on Asunción (43 ha) and San Roque (37 ha) islands, in El Vizcaíno Biosphere Reserve, off Baja California, Mexico. Black-vented Shearwater (*Puffinus opisthomelas*), Xantus's Murrelet (*Synthliboramphus hypoleucus*), Cassin's Auklet (*Ptychoramphus aleuticus*), Heermann's Gull (*Larus heermanni*), and Elegant Tern (*Thalasseus elegans*) have nested in

these islands. However, the presence of introduced cats and rats during decades decimated and, in some cases, extirpated seabird populations. With the eradication of invasive cats and rodents during the last decade, both islands became a safe habitat for birds to return. To attract back extirpated seabird populations, a restoration project started on Asunción and San Roque in 2008, continues to date and will continue with a long term perspective. The project involves the use of social attraction systems, comprising Elegant Tern and Heermann's Gull decoys, vocalization playbacks powered by solar panels, mirrors, and monitoring of seabirds and land birds. Results to date are positive and encouraging. Interactions of Elegant Tern with decoys have been recorded as well as the presence of Heermann's Gull nests (36), next to the attraction systems. The recolonization of Cassin's Auklet and Brown Pelicans (*Pelecanus occidentalis*) have been confirmed. Craveri's Murrelet (*Synthliboramphus craveri*) is also nesting on the islands. The data gathered set the basis to integrate a long-term restoration program on the other Mexican Pacific islands, from Coronado islands in the North to Asunción in the South, that benefit seabird populations distributed along the wide US-México international region. For the purpose multiannual funds have been secured thanks to two US compensation trusts (Montrose and Luckenbach) and commitments from Mexican government agencies and private donors. An Environmental Education program with the local communities will be a crucial element for the long-term success. The project involves collaboration between US and Mexican government agencies, donors and local fishermen communities.

#### SEABIRD BYCATCH IN ALASKA TRAWL FISHERIES - A COMPARISON OF OBSERVER SAMPLING PROTOCOLS.

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Seabird bycatch in Alaskan trawl fisheries average 1,300 birds per year. Estimates are based on the fisheries observer species composition data obtained from sampling the catch. Observers noted additional mortalities occurred, due to interactions with vessel gear, which were outside the standard sample and not accounted for. Other studies also indicated bycatch occurred from these causes. An observer special project was completed in 2004-2006 and 2009 to determine the degree of unmonitored mortality from these sources. Data were collected throughout the trawl fleet covering all regions, fishing modes (catcher vessel or catcher processor), targets, and operational attributes. This analysis uses 9,395 hauls where the observer completed both the standard and special project (supplemental) sampling. Seabird bycatch was documented in 400 hauls (<5%) and included 839 seabirds. There were 3.5 times as many birds in the supplemental versus the standard sample (651 vs 188). To evaluate at the haul level, we extrapolated the standard sample and compared it to the supplemental data collected for the same haul. The average seabird bycatch rate (birds/haul) from the standard samples was  $0.020 \pm 0.007$  (95% CI). The total rate when supplemental data were included was  $0.098 \pm 0.012$  (95% CI). This rate is four times higher than available data used for fleet-wide seabird bycatch estimation. Rates differ by species groups and within various partitions of the trawl fleet. Observers now record these additional mortalities and we are evaluating how to use these data for improved trawl fishery seabird bycatch estimates.

#### THE EFFECTS OF SUPPLEMENTAL FEEDING ON THE PHYSIOLOGY OF ATLANTIC PUFFIN (FRATERCULA ARCTICA) PARENTS

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Atlantic puffins (*Fratercula arctica*) are monogamous, long-lived seabirds that have obligate biparental care of their one chick. As environmental conditions are variable, it is important for adults to be flexible in their parenting behaviour if a chick is to be successfully fledged. Adult pairs share the responsibilities of parental care; however individual investment varies within pairs. A supplemental feeding study examining adult physiology was conducted on Gull Island, Newfoundland to investigate the differences in partner responses to varying chick-feeding demands. A group (N=50) of adult puffins were studied, in which half of the groups chicks were fed two capelin (preferred prey) and the other half were unfed (control group). After 14 days, blood was taken to measure corticosterone, a stress hormone, and beta-hydroxybutyrate, a lipid metabolite indicating starvation, in adults. It is predicted that adults with supplemental fed chicks will have lower corticosterone levels, as provisioning requirements are reduced and foraging is less stressful. As well, lower beta-hydroxybutyrate levels are predicted, as there is less need to minimize self-feeding and use stored lipids. Results from this study show that adult males (but not females) with supplemental fed chicks have significantly lower corticosterone levels than adults with control chicks, while adult females (but not males) with supplemental fed chicks have significantly lower beta-hydroxybutyrate levels than adults with control chicks. This suggests that there are sex differences in parental investment strategies of puffins. I will discuss the links between sex differences and physiology when chick-feeding demands alter provisioning behaviour of parents.

## TOO BIG TO FAIL – PROTECTING AN ECOSYSTEM THAT TRANSCENDS EXISTING MANAGEMENT STRUCTURES

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The 14 million resident seabirds of the Central tropical Pacific are primarily pelagic feeders that obtain the fish and squid they consume by associating with schools of large tuna and billfish. They belong to a dynamic community of species using both static and spatially shifting hydrographic features that define their range. The size of this system dwarfs any management structures we have in place to protect it. Impediments to maintaining the system's structure and function include: 1. That this ecosystem remains one of the least well studied and most poorly understood on earth. 2. That multiple jurisdictions and international waters necessitate operating with the cumbersome methods of international diplomacy; and 3. That efforts to incorporate "ecosystem" objectives into existing management of various ocean uses have suffered from our inability to identify the states or variables in a complex system that can be feasibly measured and managed. Approaches to ocean governance include the creation of marine protected areas (MPAs) encompassing persistent hydrographic features. Four new Marine National Monuments in the Central Pacific protecting 336,000 square miles represent an area greater than twice the size of the entire US National Park system yet these and other large MPAs protect only between 0.5 and 1 percent of the total area of the seas and are not sufficient. Other proposals, including establishing dynamic MPAs defined by water masses or by regulating specific ocean uses such as tuna fisheries, require more

information about foraging range and behavior of seabirds and their prey to effectively apply management that will perpetuate this system.

## HOW DO WATER MASSES INFLUENCE THE SEABIRD COMMUNITY IN THE NORTHEASTERN CHUKCHI SEA?

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We examined relationships between oceanography and the distribution and abundance of seabirds in the northeastern Chukchi Sea in 2008–2010 as part of a multi-year, interdisciplinary study (Chukchi Sea Environmental Studies Program). We conducted boat-based surveys in 3 study areas located in the offshore northeastern Chukchi Sea known as Klondike, Burger, and Statoil. The total density of seabirds was considerably higher in 2009 than it was in 2008 or 2010 and generally was higher in Klondike than in Burger in 2008 and 2009; densities did not differ significantly among Klondike, Burger, and Statoil in 2010. Species-composition varied among study areas, seasons, and years. The numerical dominance of alcids in all study areas combined increased from 2008 to 2010. Klondike was numerically dominated by alcids and tubenoses in all years, whereas Burger was numerically dominated by larids and tubenoses in 2008 and by alcids in 2009 and 2010; Statoil also was numerically dominated by alcids in 2010. The distribution of seabirds, particularly the planktivorous species, may be strongly influenced by advective processes that transport oceanic species of zooplankton from the Bering Sea to the Chukchi Sea. This transport apparently differed among years and resulted in a broader northeastward intrusion of Bering Sea Water, higher abundance of large oceanic copepods and euphausiids, and greater abundance of planktivorous seabirds in both study areas, in 2009 than in 2008 or 2010.

## CAUSES AND CONSEQUENCES OF HIGHLY VARIABLE DIETS FOR COMMON MURRES OFF OREGON

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In many regions throughout their range, common murres (*Uria aalge*) exhibit narrow dietary preferences and are vulnerable to recruitment failures of a dominant prey species during the breeding season. Contrastingly, common murres nesting in the Northern California Current off Oregon, exhibit high prey species diversity and variability in dominant prey consumed. We studied the diets of common murres between 1999 and 2011, a period in which the northern California Current experienced dramatic inter-annual variability in ocean conditions, including both delayed and intensified upwelling, anomalous near-shore hypoxia, and decoupling of conditions between northern and southern regions. Likewise, murre diets varied considerably. While clupeids were an important diet component throughout the study period, murre diets were dominated in some years by Pacific sand lance (*Ammodytes hexapterus*) and other years by Osmerids (likely *Allosmerus elongatus* and *Hypomesus pretiosus*). Inter-annual variation in prey species diversity in murre chick diets appears to be influenced by environmental drivers at basin and

local spatial scales. For example, the occurrence of osmerids and clupeids in murre diets were positively correlated with the preceding fall and winter Multivariate El Nino Index (MEI) throughout the study period, while the year in which sandlance dominated the diets was characterized by negative anomalies in local winter water temperatures and an early spring transition. Although the common murre colonies on the central Oregon coast may be able to buffer some effects of environmental variability, they also face increasing incidences of avian predator disturbance.

#### PICK YOUR POISON: PATTERNS OF PERSISTENT ORGANIC POLLUTANTS IN RHINOCEROS AUKLET PREY AMONG BREEDING COLONIES IN WASHINGTON STATE

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Seabird diet and foraging ecology have long been linked to coastal marine environments, reflecting status and condition of seabirds as well as prey availability, population status, fishery recruitment, and indicators of marine ecosystem health. Toxic contaminants in seabird prey may also reflect seabird and marine ecosystem health, particularly as pollutants can biomagnify up food chains. In Puget Sound, elevated levels of many contaminants have been documented in Pacific herring as well as upper trophic level predators, including Pacific salmon, harbor seals, and killer whales. We collected data on persistent organic pollutants (POPs) in prey obtained from rhinoceros auklets to test the hypothesis that contaminant loads differed among fish collected at breeding colonies in Puget Sound (inland waters, apparently in decline), on Destruction Island (outer coast, relatively undisturbed), and on Tatoosh Island (intermediate location, inland water and outer coast influences). We measured levels of PCBs (polychlorinated biphenyls), DDT (dichloro-diphenyl-trichloroethane), PBDEs (polybrominated diphenyl ethers), and other organochlorine pesticides for the main prey species (Pacific sandlance, Pacific herring, Chinook and chum salmon, surf smelt, anchovy, rockfish). Although patterns in POPs were variable, some results suggested depressed marine ecosystem health in Puget Sound (PCBs in sandlance and surf smelt). Other contaminants were as great or greater in some outer coast prey samples, perhaps reflecting regional (Columbia River) influences. We advocate sampling breeding auklets and other resident seabirds to further compare the different marine environments and to examine biomagnification effects in local species and the potential for developing seabird contaminant indicators for the Puget Sound.

#### FORAGING MOVEMENTS AND DIET OF GULL-BILLED TERNS NESTING IN SAN DIEGO BAY, CALIFORNIA: IMPLICATIONS FOR CONSERVATION AND MANAGEMENT

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Gull-billed terns (*Gelochelidon nilotica vanrossemi*) are dietary generalists that habitat switch and forage at multiple trophic levels. They are the only known coastal tern species to prey upon terrestrial vertebrates, e.g. various species of lizards and the young of coastal birds. In San Diego, this intraguild predation of California Least tern and Western Snowy Plover chicks, both of which have U.S. Endangered Species Act status, has created controversy and concern for conservation and management of all three species involved.

In 2010, we initiated a project to investigate foraging movements and diet of Gull-billed terns nesting in San Diego. The goals of this project are two-fold: elucidate information on individual Gull-billed tern foraging movement during the breeding season, and determine both adult and chick diet. Using radio telemetry, we were able to document radio-tagged Gull-billed tern frequency of attendance at three California Least tern colonies and one Western Snowy Plover breeding site. Gull-billed terns were highly active at night, a first ever documentation of this behavior for the species, with individuals visiting the aforementioned breeding sites between the hours of 2100 to 0400. Preliminary evidence indicates Gull-billed terns have gender-specific foraging differences and supports speculation that some type of temporary foraging territory strategy may be utilized by Gull-billed terns in San Diego to partition available foraging habitat. Possessing information on the spatial use of foraging habitats of mesopredators, e.g. Gull-billed terns, is critical for the design of effective conservation and management strategies for at-risk species.

#### TROPHIC INTERACTIONS AND VARIATION IN REPRODUCTIVE PERFORMANCE WITHIN A COMMUNITY OF ANTARCTIC PENGUINS (GENUS *PYGOSCELIS*)

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The southwestern Atlantic sector of the Southern Ocean including the Bellingshausen Sea west of the Antarctica Peninsula (AP) is now strongly influenced by ocean-climate warming. Marine community responses to western AP regional warming are now clearly evident. Especially marked are breeding population responses by the *Pygoscelis* penguins including the sea ice-obligate Adélie penguin (*P. adeliae*) and the sea ice-intolerant gentoo (*P. papua*) and chinstrap (*P. antarctica*) penguins, which are demonstrating pole-ward shifts in bio-geographic range. Using data over the 2008-2010 austral summers, we examine nutritional correlates of variation in individual reproductive performance of all species nesting near Anvers Island, Antarctica. In addition, we consider latitudinal variation in reproductive performance among Adélie penguins nesting at Avian and Charcot Islands, southern AP regions where sea ice remains a prominent physical feature. Three primary analyses are presented utilizing carbon ( $\delta^{13}\text{C}$ ) and nitrogen ( $\delta^{15}\text{N}$ ) stable isotope signatures as proxies of marine trophic structure. (1) Isotope signatures of red blood cells (RBCs) obtained from pairs of adults at the one-egg stage are coupled with data from field studies of body condition to examine nutritional correlates of primary reproductive effort (timing of nesting and egg size). (2) RBC isotope signatures of chicks at day 5, 15 and 5 weeks also are coupled with field studies of body condition to examine nutritional correlates of secondary reproductive effort. Finally, (3) models of latitudinal variation in marine trophic structure are developed and employ isotopic mixing models to quantify the relative proportions of various prey items to chick production.

#### HORMONAL EFFECTS OF THE “CYCLE OF VIOLENCE” IN NAZCA BOOBY NESTLINGS

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Non-breeding Nazca booby (*Sula granti*) adults exhibit an unusual and intense social attraction to non-familial conspecific nestlings. Non-parental Adult Visitors (NAVs) seek out and approach unguarded



nestlings during daylight hours and display parental, aggressive, and/or sexual behavior. In a striking parallel to the "cycle of violence" of human biology, degree of victimization as a nestling is strongly correlated with frequency of future maltreatment behavior exhibited as an adult. We investigate candidates for permanent organization of this behavior, including immediate and long-term changes in circulating corticosterone and testosterone due to victimization, by protecting some nestlings with portable enclosures that prevented NAV visits and comparing them to controls. During maltreatment episodes, nestlings experience an approximate five-fold increase in corticosterone concentration, and corticosterone remains elevated until at least the following morning. No effect on growth, acute or chronic changes in testosterone, or chronic CORT elevation was detected or appeared to be components of an organizational effect. Our results are consistent with the possibility that repeated activation of the hypothalamic-pituitary-adrenal axis permanently organizes future adult maltreatment behavior.

#### NEWELL'S SHEARWATER POPULATION MODELING: WHAT DOES POTENTIAL RECOVERY LOOK LIKE?

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The Newell's shearwater (*Puffinus newelli*), an ESA listed species, faces terrestrial threats from predation, attraction to artificial lights and collision with powerlines. Population modeling was conducted for HCP and recovery planning to consider the benefits of management actions to the Kauai population. Population scenarios modeled included a) stable, realistic and optimal growth; b) threats of predation, fallout and powerline collision; and c) management actions of minimizing fallout and powerline mortality, predator control, predator eradication and chick translocation. The growth rate produced in our worst case threat scenario for all threats (0.906) fell within the range of annual change suggested by ornithological radar data from 1993-2010 using only Newell's shearwater traffic (0.899), and Save Our Shearwater data of Newell's shearwater fledglings from 1988-2009 (0.905). Combined management scenarios with 1) 10% population subjected to predator control, 5% to predator eradication, and 100 chicks translocated over five years, and 2) 20% population subjected to predator control, 10% to predator eradication, and 400 chicks translocated over 10 years, would provide an estimated net benefit of 2,000 - 4,000 birds over 25 years, compared to no management undertaken. Combined management actions likely to provide the greatest potential benefit should be targeted to prevent this species from becoming extinct, including predator control of Northwest colonies, predator eradication projects in combination with aggressive powerline and fallout minimization in the same region, and chick translocation to threat-free environments.

#### ALBATROSS-FISHERY OVERLAP IN THE U.S. WEST COAST GROUND FISH FISHERIES

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A short-tailed albatross (*Phoebastria albatrus*) mortality in the hook-and-line sablefish fishery in 2011 and an increase in annual sightings has triggered conservation concern for this endangered species in the

West Coast groundfish fisheries. Annual mortalities of black-footed albatross (*P. nigripes*) in these fisheries reinforce this concern. We used seabird distribution data from 64,014 km of ship-based surveys (2005 to 2008) and fishing effort data (2002 to 2009) derived from at-sea fishery observers to determine the exposure of North Pacific albatrosses to six West Coast groundfish fisheries (two longline and four trawl) by management area (north to south) and bathymetric domain. Exposure was the product of total fishing effort (hooks or towing hours) and mean albatross density in at-sea surveys. Short-tailed albatross were rare in surveys, so we compared available satellite telemetry data from short-tailed, black-footed and Laysan (*P. immutabilis*) albatrosses. We found that black-footed and short-tailed albatrosses shared similar distributions, permitting the use of black-footed albatross distributions as a surrogate for short-tailed. Both spent the most time over the shelf-break from central California to northern Washington. Results suggest that albatross exposure is highest in longline and trawl sectors that occur over the shelf-break (200-1,000 m) from the Monterey management area (36° N lat.) to the Canadian border. The shelf-break in the Columbia management area was identified as an area of high exposure for trawl and hook-and-line fisheries. These results provide tools to target management action to conserve short-tailed albatross in these fisheries.

#### THE MIGRATION AND NON BREEDING MOVEMENTS OF ARCTIC TERNS (*STERNA PARADISEAE*) NESTING IN THE GULF OF MAINE

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Thirty miniature (1.4g) geolocators were attached to leg bands of nesting Arctic Terns on two islands in coastal Maine to determine migration timing and duration, and movement/staging patterns. Eleven units yielded data, nine recorded the full migration. Two distinct southward movement patterns are evident; all birds initially moved east, eventually diverging, south of the Azores with one group moving south along the West African coast and the other crossing to the coast of South America and proceeding south. Return migration routes were similar for all birds, with each following a sigmoid pattern from the Antarctic Peninsula to Africa, crossing the equatorial zone into the western Atlantic. Three distinct areas staging areas were evident, one in the central North Atlantic (during the southern migration, although 1 northbound migrant staged here for 15 d), one previously unrecognized area off the Uruguay/Argentina coast and another in the Weddel Sea.

#### TRACKING NON-BREEDING MOVEMENTS OF ATLANTIC PUFFIN IN THE WESTERN NORTH ATLANTIC

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While technology has shed light on the migrations of birds ranging in size from albatross to hummingbirds, little is known about the movements of small diving seabirds such as Atlantic Puffins

(*Fratercula arctica*). To learn where puffins winter, we tested methods for attaching geolocators to puffins and recovering these in subsequent years. In 2009, eight Lotek LAT 2500 geolocator tags were placed on breeding Atlantic Puffins at Seal Island National Wildlife Refuge in mid-coast Maine USA. These were attached using UV resistant wire ties to plastic Darvic Bands. Five of the eight were sighted still carrying the geolocators near their burrows in 2010, but none nested (which was unusual for puffins). In 2010, 18 Lotek NANO geolocators (LAT 2900) were attached with similar DARVIC UV resistant leg bands with plastic wire ties to breeding puffins at nearby Matinicus Rock. At 17mm long, these tags were less than half the length of the larger LAT 2500 units and at 2grams about half the weight. Fourteen of these were recovered from breeding puffins in 2011 and two of the 2009 units were recovered from puffins that were still not nesting at Seal Island. Removal of the larger tags revealed moderate to extreme leg damage; no damage was noted on the 14 puffins carrying the smaller LAT 2900 units. Most of the 16 recovered geolocators have incomplete data records associated with variable battery life, but all hold potentially useful data for revealing the non-breeding habitat occupied by puffins in the western North Atlantic.

#### SILENT STRESSORS: SUBLETHAL INORGANIC CONTAMINANTS IN PACIFIC SCOTERS

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Over the last 30 to 50 years, populations have declined by an estimated 60%. Until recently, surf scoters (SUSC; *Melanitta perspicillata*), and its two congeners white-winged scoters (WWSC; *Melanitta fusca*), and black scoters (*Melanitta nigra*) were censused together without interspecific distinction. Thus, it is unknown which of the three species is driving the decline. Focusing on surf and white-winged scoters in the Pacific Northwest, previous studies found that habitat quality did not entirely explain their body condition (as size and metabolic biomarkers). Clearly, other factors constrain body condition and may contribute to population dynamics. We investigated the potential correlation between chronic exposure to sub-lethal metals concentrations and the body condition of surf and white-winged scoters. Data analysis is ongoing. Initial findings show that because of high variance, there were no interspecific differences in male livers for either selenium (Avg  $\pm$  SD, SUSC: 238  $\pm$  117  $\mu$ Mol/kg dw; WWSC: 275  $\pm$  91  $\mu$ Mol/kg dw) or mercury (Avg  $\pm$  SD, SUSC: 6.0  $\pm$  4.5  $\mu$ Mol/kg dw; WWSC: 11.7  $\pm$  7.7  $\mu$ Mol/kg dw). However, the trend for mercury concentrations in SUSC to be approximately half that of WWSC suggests that their dietary shift to herring spawn may minimize their exposure to mercury. Generally high body burdens of contaminants indicate that industrial output in the region may be affecting the quality of critical wildlife habitat. Analyses are underway to compare mercury and selenium concentrations in blood samples comparing birds from the Puget Sound-Georgia Basin region to birds living in non-industrialized sites in Southeast Alaska.

#### POTENTIAL IMPACTS TO MARBLED MURRELETS (*Brachyramphus marmoratus*) FROM WIND ENERGY DEVELOPMENTS ON THE WEST COAST OF NORTH AMERICA.

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The Marbled Murrelet (*Brachyramphus marmoratus*) is a medium-sized Pacific seabird that nests at inland sites over a range of approximately 4,800 km of coastline from the Aleutian Islands of Alaska, through British Columbia, Washington and Oregon, south to central California. This species is known to nest as far as 60 km inland in some regions. With the unprecedented growth of the wind energy industry and the ubiquity of viable sites along the Pacific coast which are rated “good” or better for wind generation, there will be increasing demand to develop offshore and onshore wind resources in areas where murrelets may be flying. The potential for wind energy development to negatively impact birds and bats is well documented, with mortality due to turbine strikes a major concern and displacement from foraging or nesting habitat a secondary concern. The unique biology and aeroecology of the murrelet exposes this species to higher relative collision risk when compared to other groups of birds. The unique life history traits that increase risk for this seabird include: both adults transiting inland to feed young, non-breeders transiting inland to visit nesting areas, multiple feeding visits by adults as young mature that include evening flights, and winter visitation to nesting areas. In addition, the unique aeroecology of this species includes dawn and dusk flights in low light conditions, often through coastal fog, and a flight height distribution that is much lower when compared to a typical nocturnal migrating bird. As wind energy projects are developed along the west coast, there will be a need for cumulative effects analysis of these projects on local and regional populations.

#### DIET ANALYSIS OF THE DOUBLE-CRESTED CORMORANT (PHALACROCORAX AURITUS ALBOCILIATUS) IN THE SAN DIEGO BAY NATIONAL WILDLIFE REFUGE

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Seabirds with a generalist diet are more likely to reflect available prey assemblages, as they often sample the most abundant prey species from a range of trophic levels. This study proposes to evaluate the diet of both adult and chick Double-crested Cormorant (*Phalacrocorax auritus albociliatus*) for the purpose of establishing local baseline prey availability for the San Diego region and evaluate the use of Double-crested cormorants as a regional surrogate species for several seabirds of conservation concern nesting and wintering in San Diego.

The study location will be the South Bay Unit of the San Diego National Wildlife Refuge, one of the few stable nesting colonies for Double-crested Cormorants in San Diego County. Previous research indicates that this species of Cormorant preys on 250 or more fish species, making them a good choice for evaluation as a surrogate for other local piscivore seabird diets. Surrogate species have often been used as habitat suitability indicators for other members of their guild for purposes of conservation and management. Additionally, no diet studies for Double-crested Cormorants exist south of Santa Barbara and north of San Martin Island in Mexico.

Research such as this study is needed not only to better understand the ecological niche and resources that the Double-crested Cormorant consumes in San Diego, but will also provide crucial information about activity in several ecosystems at different trophic levels which can inform conservation and management purposes for both nesting seabirds and prey fish species in San Diego.

## ASPECTS OF MARBLED MURRELET BIOLOGY FROM LAYING TO HATCHING

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Aspects of the nesting biology of Marbled Murrelets (*Brachyramphus marmoratus*), from laying to hatching, were studied in Redwood National and State Parks, Humboldt County, in northern California, in 2001 – 2003, using radio-telemetry and video recordings at nest sites. Mean nest initiation dates were 23 May (2001, n = 6 nests), 10 June (2002, n = 15 nests) and 24 May (2003, n = 8 nests). Egg laying occurred prior to 06:30h (n = 3), and the first incubation shift was taken by the male (n = 4). Most murrelets (67%) exhibited 24 h incubation bouts followed by 24h at sea. Of the remaining nine birds, seven exhibited an irregular incubation pattern, skipping at least one day of incubation within the first five days of incubation. Males and females had similar incubation patterns, but females with regular incubation patterns were significantly heavier at capture than females with irregular incubation patterns. There was a tendency ( $P < 0.06$ ) for daily survival probabilities of nests to be lower in the first 12 days of incubation compared to the last 12 days, and the number of nests failing in the first 12 days of incubation compared to the last 12 days of incubation. Hatching success averaged 37.9% (range: 25-50). Hatching success was greater for early nests (%) compared to later nests (%). Nests were more likely to fail earlier in the incubation period (%) compared to later. Hatching success was not effected by hatching pattern.

## ASSOCIATIONS BETWEEN SEABIRDS AND SUBSURFACE PREDATORS AROUND O'AHU, HAWAII

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Many species of tropical seabirds rely on subsurface predators such as tuna and dolphins to drive prey close to the ocean's surface. We observed seabird foraging events from fishing vessels around O'ahu, Hawai'i, during summer – fall (June – November) of three years (2000, 2001, 2003) to determine the prevalence and relative importance of subsurface predators to seabird foraging. The presence and/or identity of subsurface predators was determined in 62 of the 69 seabird foraging events observed. Over 96.7% (60) of these events involved subsurface predators and accounted for 99.8% of all foraging birds. Skipjack tuna (*Katsuwonus pelamis*) were the predominant (81%) subsurface predator involved in seabird feeding events, with odontocetes (*Stenella attenuata* and *Pseudorca crassidens*) (8%), mahi-mahi (*Coryphaena hippurus*) (6%), and yellowfin tuna *Thunnus albacares* (2%) being less common. Wedge-tailed shearwaters *Puffinus pacificus* (75.3%) and brown noddies (*Anous stolidus*) (14.3%) foraged in association with tuna schools more often than would be expected by chance. In contrast, Red-footed boobies (*Sula sula*), did not associate with any subsurface predator in greater proportion than what would be expected by chance. Nine additional seabird species were observed foraging in association with subsurface predators, but not in numbers large enough for statistical analysis. This study highlights the need for regional studies of the multi-species feeding flock dynamics and seabird–associations with

subsurface-predators. Furthermore, evidence that at least 2 species of seabirds show tight associations with skipjack tuna around O'ahu, highlights the need for a broader ecosystem-based assessment of the potential indirect ecological effects of tuna fisheries.

## TROPICAL JAEGER? DISTRIBUTION, ABUNDANCE, AND TRENDS IN THE EASTERN TROPICAL PACIFIC OCEAN

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Jaegers (*Stercorarius* spp.) are typically considered to be birds of high latitude habitat and are particularly well studied on their breeding grounds. Much less is known about their wintering habitat and distribution. We conducted a seabird survey aboard NOAA Fisheries ships during 5 years over a 9-year time span (1998-2006) in the oceanic eastern tropical Pacific (ETP), an area of 21 million km<sup>2</sup>. The cruises were part of a multi-year cetacean and ecosystem assessment study designed to assess the status of dolphin stocks incidentally affected by the yellowfin tuna purse-seine fishery. We used standard 300m strip transect methods and recorded seabirds continuously during all daylight hours, weather permitting. All cruises were conducted August-November, coincidental with jaeger migration to tropical oceans for the boreal winter. The Pomarine Jaeger (*S. pomarinus*) was the most commonly seen species, accounting for 49% of all jaeger sightings identifiable to species (n=490 sightings), followed by Parasitic (*S. parasiticus*; 35%; n=353) and Long-tailed (*S. longicauda*; 16%; n=162). The number of sightings for each species more than doubled from 1998 to 2006: Pomarine sightings increased 3.6 fold (43 in 1998; 144 in 2006); Parasitic sightings increased 2.9 fold (28 in 1998; 80 in 2006); and Long-tailed Jaeger sightings increased 2.1 fold (22 in 1998; 46 in 2006). The highest number of Pomarine and Parasitic Jaeger sightings occurred in 2000 (n=148 and 100, respectively) and Long-tailed Jaeger sightings peaked in 2006 (n=46). All three species were sighted throughout the study area, although there was a slight preference by Pomarine Jaegers for continental shelf waters, by Parasitic Jaegers for regions in the southern (ETP), and by Long-tailed Jaegers for oceanic waters. These sightings provide the first insight to jaeger wintering habitat use and distribution in the ETP.

## FROM SUBTROPICAL TO EASTERN BOUNDARY: SUCCESSFUL LONG DISTANCE BREEDING RANGE EXPANSION OF A TOP MARINE CONSUMER THE LAYSAN ALBATROSS (*PHOEBASTRIA IMMUTABILIS*)

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We use electronic tagging and remote sensing data from Laysan albatross (*Phoebastria immutabilis*) breeding at a historical Central Pacific colony (Tern Island, USA) and a newly established, Eastern Pacific colony (Guadalupe Island, Mexico) to examine the consequences of range expansion on albatross distribution, foraging habitat characteristics, habitat use, and foraging behavior at sea during the incubating, brooding, chick-rearing, and post-breeding stages. We explore the consequences of this range expansion on population growth. During the breeding season albatrosses from the different colonies forage in contrasting oceanographic habitats where Central birds utilize the North Pacific Transition Zone and Transition Zone Chlorophyll Front while Eastern birds utilize features of the California Current System, an eastern boundary current. The relationship between a suite of environmental variables and distance to colony was significantly different between the two colonies. We used Maximum Entropy to model the importance of environmental variables to each colony during the four breeding stages. AUC values ranged between 0.77-0.855, demonstrating relatively good discrimination for all models. Both model results and density plots of variables show birds from each colony utilize environmental variables of different values. Reproductive success and population growth is greatest at the new Eastern colony. This recent range expansion provides the opportunity to examine the consequences of large-scale range shifts on the foraging and breeding ecology of seabirds as might be experienced in the context of climate change.

#### ARTIFICIAL LIGHTS IN FISHING PORT AFFECT PREY DENSITY AND NOCTURNAL FORAGING BEHAVIOR OF GULLS

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Artificial lights provide nocturnal foraging opportunities for usually diurnal predators. The density of diurnal seabird can be affected by artificial light (fish collecting lamps and outdoor lamps along the coast) since these lights change the behavior of their prey species (zooplankton and small fish). Empirical field studies covering multiple trophic levels, however, have not been carried out. We observed nocturnal foraging behavior of gulls in 12 fishing ports in Hakodate, Hokkaido, and also measured seasonal changes in the number of gulls and density of zooplankton under an artificial light at Hiura port. More nocturnal foraging gulls were observed in ports with more lights. The percentage of nocturnal foraging individuals and the density of zooplankton (oviferous amphipods) were higher under the light than the surrounding surface water. More nocturnal foraging gulls were observed in January-May when the density of zooplankton was higher than July-December. These indicate that the lights in port attract zooplankton and enhance nocturnal foraging gulls.

#### CONSERVATION STATUS OF TROPICAL SEABIRDS AND GUIDING REMOVAL OF INVASIVE VERTEBRATES ON ISLANDS



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Seabirds are the most foremost threatened group of birds, with 28% of species identified at risk of extinction. An estimated 70% of seabirds are exposed to terrestrial threats on their breeding islands, with invasive vertebrates widely documented as a critical threatening process. We worked with numerous partners to build a database of island populations of IUCN Threatened seabirds and other vertebrates, with an overall goal of identifying and prioritizing islands where removal of invasive vertebrates can maximize recovery potential of threatened species. We collated information for Critically Endangered, Endangered and Vulnerable seabird species, recommended conservation actions for each species by Birdlife, the number and location of breeding islands for each species, and presence of invasive vertebrates on these breeding islands. A total of 30 species breed on islands between the tropics of Capricorn and Cancer, with *Procellariidae* representing 16 of these species, highlighting this family as conservation concern in the tropics. A total of 157 breeding islands were identified, with invasive vertebrates were recorded on at least 75% of islands. Threatened tropical seabird breeding islands were geographically and politically clustered, with the five species recorded in both the Galápagos Archipelago and French Polynesia. Our results suggest that programmatic approaches to invasive species eradications in key areas can efficiently protect threatened tropical seabirds.

## BRYAN'S SHEARWATERS HAVE SURVIVED IN THE BONIN ISLANDS, NORTHWESTERN PACIFIC!

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The Bryan's Shearwater (*Puffinus bryani*) is a new species described in 2011 based on a specimen collected in Midway Atoll in 1963 (Pyle et al. 2011). This specimen and another recorded at Midway Atoll in the early 1990s are the sole reliable records to date. Bryan's Shearwaters likely do not regularly breed in the Northwestern Hawaiian Islands because of the limited number of records. The Bonin Islands are subtropical oceanic islands located in the northwestern Pacific Ocean at a similar latitude to Midway. Since 1997, we have found six samples of remarkably small *Puffinus* shearwater (one rescued individual and five carcasses) which showed similar morphological characteristics to the Bryan's Shearwater. In this study, we genetically and morphologically examined the Bonin samples and have confirmed that they are the Bryan's Shearwaters. Since the latest sample was found on an islet to the north of Chichijima Island in 2011, the species have surely survived there. There is thus a strong possibility that the Bonin Islands provide their breeding grounds, although the exact locations remain unclear. Three of the examined individuals found on an islet off Chichijima Island were detected as carcasses preyed upon by Black Rats (*Rattus rattus*). Although attempts were made to eradicate rats on this island in 2008, there are various other rat-infested islands that could be breeding grounds for shearwaters. In any case, Bryan's Shearwater

appears to be very rare and threatened in the Bonin Islands. For its conservation, detection of their breeding sites and rat eradication are essential.

## EFFECTS OF BALD EAGLE DISTURBANCE ON COMMON MURRE BREEDING AT YAQUINA HEAD, OREGON

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Yaquina Head supports one of the largest and most productive common murre (*Uria aalge*) breeding colonies on the Oregon coast, yet it is also subject to considerable disturbance by bald eagles (*Haliaeetus leucocephalus*). Data collected between 2007 and 2011 indicate that disturbances caused by adult and sub-adult bald eagles have increased at this site, with the greatest increase in reproductive loss due to predators in 2011. During a disturbance, direct predation by eagles has a limited impact on the breeding colony. However, indirect effects associated with murre colony evacuation and subsequent depredation by opportunistic avian nest predators can lead to hatch asynchrony and reduced reproductive success at some breeding sites. Since 2007, the assemblage of secondary predator species present at Yaquina Head has expanded to include turkey vultures (*Cathartes aura*) and juvenile California brown pelicans (*Pelecanus occidentalis californicus*), in addition to western gulls (*Larus occidentalis*), common ravens (*Corvus corax*) and American crows (*Corvus brachyrhynchos*). These species are likely being facilitated by prolonged, frequent disturbances caused by sub-adult eagles at this site. Interestingly, the majority of eagle disturbance is concentrated on certain portions of the rocks where murrees breed, thereby limiting the areas where secondary predators have access to eggs or chicks, and allowing moderate to good reproductive success throughout other areas of the colony. Although bald eagle disturbance is affecting reproductive output of murrees at Yaquina Head, reproductive success remains moderate to good overall, in contrast to many other murre colonies in the region.

## SEABIRD RESTORATION IN THE ALEUTIANS: TAKING THE RAT OUT OF RAT ISLAND

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The Aleutian Islands are among the most productive seabird breeding areas in world, providing habitat for 26 species of seabirds numbering >10 million individuals. Rats (*Rattus norvegicus* and *R. rattus*) have been introduced to several islands in the Aleutians, and those islands support far less seabird diversity and abundance than islands without rats. The US Fish and Wildlife Service partnered with The Nature Conservancy and Island Conservation to initiate a program to remove rats from the Aleutian Islands beginning with the relatively small Rat Island (2,900 ha). In late September 2008, pellets containing 25-

ppm brodifacoum were aerially broadcast. In 2010 a visit confirmed that no rats were present and that the eradication effort was a success. However, an unexpected number of Glaucous-winged Gull (*Larus glaucescens*) and Bald Eagle (*Haliaeetus leucocephalus*) carcasses were discovered and collected on Rat Island in 2009, most of which were confirmed or suspected to have been exposed to the rodenticide. Results from ecosystem monitoring in 2010 and 2011 have shown the first evidence of Aleutian song sparrows (*Melospiza melodia maxima*) returning to the island and successful nesting of Glaucous-winged Gulls, Black Oystercatchers (*Haematopus bachmani*), Common Eider (*Somateria mollissima*), Pigeon Guillemot (*Cepphus columba*) and Red-faced Cormorant (*Phalacrocorax urile*) among other species. Bald Eagle territorial pairs were also observed. Acoustic surveys have detected Leach's and Fork-tailed storm-petrels (*Oceanodroma leucorhoa* and *O. furcata*) flying over potential nesting habitat on Rat island. These findings indicate that the recovery of Rat Island is in progress.

## CAN NEARSHORE FORAGING SEABIRDS DETECT CHANGE IN FISH DISTRIBUTION IN AND AROUND COASTAL MARINE RESERVES?

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California's Marine Life Protection Act mandates establishing a network of marine protected areas (MPAs) throughout the state. As new MPAs mature, there will be a need not only to detect change in several levels of community structure, but to establish efficiencies among monitoring programs to maximize coverage throughout the state. Here we ask whether seabird foraging distributions can be a proxy for fish distribution around a marine reserve in central California. We investigated the foraging distributions of five piscivorous seabirds during April-August of 2007-2011. We conducted weekly foraging surveys inside, adjacent to, and distant from the reserve. Additionally, we characterized kelp forest fish distributions using data from diver surveys conducted in 2008. Four seabird species foraged more outside the reserve than inside, while there were no reserve effects for the fifth. Additionally, there were differences in fish species diversity and size class structure with higher diversity and smaller fishes more prevalent outside the reserve. The five seabirds in our study prey mostly on these smaller fishes. The site with the highest seabird foraging rates was located within a larval retention zone where fish recruitment is likely to be enhanced. It therefore makes sense that we found them foraging mostly at this site. Our results suggest a potential for using nearshore foraging seabirds as indicators of fish recruitment to coastal habitats. Thus, while seabird foraging may not indicate changes in overall fish abundance, it may be valuable in understanding the mechanisms (e.g., recruitment) driving these changes.

## EXAMINING THE POTENTIAL TO PREDICT EL NIÑO SOUTHERN OSCILLATION USING A CULTURALLY IMPORTANT SEABIRD: SOOTY SHEARWATERS (*PUFFINUS GRISEUS*)

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Sooty shearwaters (*Puffinus griseus*; Tītī) are a species of burrow nesting seabird which breed on offshore Islands around Southern New Zealand. Sooty shearwaters play an important role in Māori culture because the nearly fledged chicks have been harvested for food for many generations. The continued harvesting of

Sooty shearwaters (i.e., ‘muttonbirding’) has led to high interest in the conservation of this species. Diaries have been maintained by ‘muttonbirding’ families, in some cases these diaries date back to the late 1930s and contain information about the number of chicks harvested per night, the number of harvesters, and basic weather. Previous work has shown that decreases in the harvest rate and burrow occupancy significantly predict a negative shift in the Southern Oscillation Index (i.e., a shift towards an El Niño condition). Since that work, new diaries have become available for analysis to examine the potential link between Sooty shearwater harvest data and El Niño events. In this study I use a sophisticated predictive algorithm (boosted regression trees) to determine the best and earliest prediction of El Niño events based on harvest data. Weather data are supplemented by daily records from the National Institute for Water and Atmospheric research in order to account for variation in harvest data due to weather events. The determination of the best and earliest prediction of El Niño by Sooty shearwaters will aid in the construction of future El Niño scenarios which has implications in many levels of society, ecology and economy.

#### SEABIRDS.NET: AN UPDATE ON PROGRESS TOWARDS A GLOBAL SEABIRD INFORMATION PORTAL

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Since the World Seabird Conference in 2010 a committee of dedicated individuals from around the globe has begun work on ‘Seabirds.net’, a website which will offer a variety of services to the global seabird community. ‘Seabirds.net’ began with a basic interface that previewed some of the upcoming applications that will be developed. Since then, a new template design has been created with an easy to use interface for anyone wishing to access functions of ‘Seabirds.net’. Inclusive of the website is PETREL, a database of professional seabird researchers, students and enthusiasts which will greatly enhance communication between these three broad groups. This presentation will outline the progress of ‘Seabirds.net’ since the 1<sup>st</sup> World Seabird Conference and the various features and functions that are being implemented.

#### BOLUSES REVEAL SPECIES-SPECIFIC AND COLONY-BASED DIFFERENCES IN PLASTIC INGESTION BY BLACK-FOOTED AND LAYSAN ALBATROSSES.

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Black-footed (*Phoebastria nigripes*, BFAL) and Laysan (*Phoebastria immutabilis*, LAAL) albatross chicks accumulate non-digestible material, including natural and plastic items, during the breeding season and regurgitate this material as a bolus. We characterized the amount and types of plastic regurgitated by albatross chicks from three Hawaiian colonies (Kure Atoll, Midway Island, Tern Island) during 2009 by dissecting 25 boluses per species/colony (sample size = 150). Bolus mass differed significantly by

species (BFAL>LAAL;  $p = 0.002$ ) and colony (Kure>Midway>Tern;  $p < 0.001$ ), with a significant ( $p < 0.001$ ) species\*colony interaction ( $R^2 = 0.443$ ). Even though every one of the 150 analyzed boluses contained plastic, the overall mass varied significantly by species (BFAL>LAAL;  $p < 0.001$ ) and colony (Kure>Midway>Tern;  $p < 0.001$ ), with a significant ( $p < 0.001$ ) species\*colony interaction and covariation with bolus mass ( $p < 0.001$ ) ( $R^2 = 0.779$ ). A principal component analysis (PCA) of 12 variables (the mass and volume of: the bolus, all plastic and four plastic types) yielded two significant ( $p = 0.001$ ) axes, which together explained 84.62% of the variability. PC1 was indicative of gradients in bolus size, overall plastic load and the abundance of foam and sheets. PC2 was indicative of gradients in the abundance of line and fragments. A PerMANOVA test revealed three significant patterns ( $p < 0.001$ ), which together explained 58.88% of the variance: species (18.88%), colony (15.29%) and their interaction (14.71%). This evidence of species-specific and colony-based differences in plastic ingestion patterns highlights the need for site-specific monitoring and research on potential impacts.

## DISTRIBUTION OF SEABIRD BYCATCH IN THE SOUTHERN HEMISPHERE

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The problems of seabird bycatch in longline fisheries are thought one of the risks of the seabird conservation. Since population of some bycatch species is vulnerable, to avoid the seabird bycatch effectively, it is crucial to understand how, which species and how many species were bycaught by commercial pelagic longliners. Our study focuses on seabird species for which BPUEs (number of bycatch / 1000 hooks) were high in southern hemisphere. With using Japanese scientific observer data from commercial tuna longline fisheries during 1997 to 2009, average BPUE values of seabirds for each 5°x5° grid cell by each season were drawn. The factors which affect to number of seabird bycatch: 1) mitigation measure, 2) co-existence of other species, 3) environment, 4) time series: year and month were discussed. Albatross bycatch was the highest in all seabird taxa. BPUE of all seabird species combined was high in south of 25 S, especially off southern African waters and in southeastern Indian Ocean. Number of albatross bycatch was affected by whether tori-line was used or not, number of white-chinned petrel bycatch, sea surface temperature and number of caught fish. The result suggest that bycatch hotspot overlap with where biomass is high.

## WORLD SEABIRD UNION: DEVELOPMENTS AND ACHIEVEMENTS SINCE THE WORLD SEABIRD CONFERENCE

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The interim body formed at the World Seabird Conference (WSC) to develop a World Seabird Union (WSU) has some 23 members, including official representatives of all 17 of the national and international organizations most involved with research and conservation of seabirds. This body meets via quarterly

conference calls to address the main objectives of the WSU, as established at the WSC, which are, in essence, to establish mechanisms for: a) a future World Seabird Conference; b) enhanced communication between seabird organizations and researchers; and c) the development and management of global seabird databases. We report on: a) the responses to questionnaires relating to the future of the WSC and initial progress towards soliciting interest in hosting another WSC; b) the development of seabirds.net (to be covered in detail in a following presentation); c) progress with establishment of global seabird databases, especially the inception of a Global Seabird Colony Register.

## THE FOSSIL RECORD OF SEABIRDS IN THE HAWAIIAN ISLANDS

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Colonial seabirds are notoriously vulnerable to predation and loss of breeding habitat in connection with human settlement of islands. Consequently, archaeological and paleontological bones can provide valuable baseline information about the prior breeding distributions, habitats, and relative abundances of seabirds on islands. We have compiled a database of over 18,000 identified seabird bones found in nearly 100 paleontological and archaeological sites, distributed across the six largest Hawaiian islands. Nineteen species are represented comprising the Diomedidae, Procellariidae, Hydrobatidae, Phaethontidae, Sulidae, Fregatidae, and Laridae. In strong contrast with the high number of extinctions recorded by bones of terrestrial birds in the same sites, only one of the seabirds has been described as an extinct species (*Pterodroma jugabilis*), testifying to the resilience of seabird populations despite their vulnerability at breeding colonies. However, many of the seabird species are not now known to breed on islands or in regions where they occur as fossils, indicating that their breeding range, and their numbers, were probably greater in the past. Bones of the Hawaiian Petrel (*Pterodroma sandwichensis*) are the most abundant in the database, composing about 70% of the total. For this species, we obtained over 150 radiocarbon dates, which provide a gripping chronology of range contraction that can be tied to human events. The distribution of species in lava caves on the younger Hawaiian islands provides insight into prior breeding habitats of the more common species in the record, and evidence of habitat segregation among them.

## MARINE SPATIAL HABITAT USE MODELS OF NEWELL'S SHEARWATER AND HAWAIIAN PETREL IN THE EASTERN TROPICAL PACIFIC.

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To investigate the marine habitat affinities of the Newell's shearwater (*Puffinus auricularis newelli*) and Hawaiian petrel (*Pterodroma sandwichensis*) in their non-breeding ranges in the eastern tropical Pacific we developed species-habitat relationship models on the basis of effort-corrected 300m strip-transect surveys and in situ oceanographic measurements. Seabird densities were measured over 1680 days and more than 93,000 km<sup>2</sup> of survey effort area aboard NOAA cetacean and ecosystem assessment cruises



conducted during eight years of surveys between 1998 and 2010 in a geographic region spanning more than 20 million km<sup>2</sup>. Environmental predictors incorporated in the selection of multivariate Generalized Additive Models included sea surface temperature, sea surface salinity, surface chlorophyll-a, thermocline strength and depth, and distance-to-colony. Interpolating selected Newell's shearwaters and Hawaiian petrel models over the study region indicated highest model densities in regions of strong thermocline primarily in the North Equatorial Counter-current. Notably, distance to colony had no effect on non-breeding densities for either species. This research contributes to our growing understanding of distribution and spatial habitat use patterns of these endangered seabirds, and will be used to generate population estimates for both species within the study region.

#### BREEDING SEASON MARINE DISTRIBUTION AND SPATIAL HABITAT USE OF NEWELL'S SHEARWATER FROM KAUA'I, HAWAII.

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We investigated broadscale marine distribution and spatial habitat use patterns of the Newell's Shearwater (*Puffinus auricularis newelli*) between Aug. 16<sup>th</sup> and Sept. 11<sup>th</sup>, 2011, by deploying nine Lotek LAT2900-1 archival Global Location Service (GLS) tags on breeding adults at their colony in the National Tropical Botanical Garden's Upper Limahuli Preserve. Tags were programmed to record daily latitude, longitude, position error, sea surface temperature, maximum pressure, and frequency of wet-dry changes, as well as to log pressure at 30 second intervals while the tag is submerged below 2m depth. Preliminary GLS tracking data from 3 individuals recovered after 16-21 days of deployment revealed that Newell's shearwaters forage north of the Hawaiian Islands to 33°N latitude on long trips between bouts of nightly feeding during the chick provisioning period. This contrasts with non-breeding migrations to the North Equatorial Countercurrent region. Dive log data from the same three individuals indicated that Newell's shearwaters dive considerably deeper than previously expected: up to 46.7 m. In addition, all dive activity occurred during daylight hours, however no significant trends in the frequency of dive activity were detected over daylight hours. This research contributes to our growing understanding of the breeding season marine distribution and spatial habitat use patterns of the threatened Newell's Shearwater.

#### INTERISLAND COMPARISON OF BEHAVIORAL TRAITS AND MORPHOLOGY OF THE ENDANGERED HAWAIIAN PETREL: EVIDENCE FOR CHARACTER DIFFERENTIATION

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The federally endangered Hawaiian Petrel (*Pterodroma sandwichensis*) breeds on the islands of Hawai'i, Maui, Lana'i, and Kauai. The species may exemplify the seabird paradox, in which a highly mobile species tends to have very low rates of dispersal among breeding colonies because of a strong degree of natal philopatry. Differentiation of morphological and behavioral characters in small geographic areas is

not unusual among petrels. To investigate the distinctness of each island population the breeding cycles, vocalizations, and morphology of Hawaiian Petrels were compared. The breeding cycles of Hawaii, Kauai, and Lanai were nearly identical; with no statistical difference in fledge dates. However, the breeding cycle of Maui commenced and concluded 26-30 days earlier than the other islands. Breeding stages were highly synchronous and rarely varied more than 10 days for each year analyzed. Vocalizations of petrels on the wing were sampled from each island. The temporal spacing of call syllables, number of syllables of each call, and the fundamental frequency of signals were quantitatively described. A total of 16 acoustic variables were tested and each island population had unique characteristics, even among geographically close colonies. Morphometric data was collected from Kauai, Maui, and Hawaii Island. Wing chord and tarsus measurements of Maui adults and fledglings were significantly longer than those of Hawaii and Kauai. Differences in behavioral and morphological characters imply taxonomic distance of island populations which may affect management decisions.

#### BREEDING ECOLOGY OF KITTLITZ'S MURRELET AT AGATTU ISLAND, ALEUTIAN ARCHIPELAGO, ALASKA, 2008-2011

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The Kittlitz's murrelet (*Brachyramphus brevirostris*) is one of the rarest breeding seabirds in the North Pacific and one of the least known in North America. During the final year of a 4-year study on the breeding biology of Kittlitz's murrelets at Agattu Island, we located and monitored 21 nests. During the nestling period, time-lapse cameras were deployed at all nests once the egg hatched and still images were used to quantify chick diets, adult attendance patterns, and nest survival. Both frequency of nest visits and types of fishes provisioned to chicks varied among nests. Of the 21 nests discovered in 2011, six chicks fledged. Chicks fledged at 24-32 days post-hatching and departure masses ranged from 104 to 139 g. Overall nest survival from clutch initiation to fledging of first nest attempts, calculated as the stage-specific rates over the incubation and nestling periods, was  $0.284 \pm 0.143$ . Compared with the three previous years of research on nesting murrelets at Agattu Island (2008-2010), breeding success was greater, chicks fledged at heavier masses, and adults made more frequent nest visits. The continued study of the murrelets breeding in the Aleutian Islands will provide further insight into the breeding biology of this rare and elusive seabird and provides a unique opportunity to elucidate its life history.

#### THE NORTH PACIFIC SEABIRD DATA PORTAL

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In the early 1990s, the Pacific Seabird Group resolved to create several shared databases for seabirds of the North Pacific region. Today, Seabirds.net provides access to the North Pacific Seabird Data Portal, an on-line web portal with two databases (North Pacific Seabird Colony Register, North Pacific Seabird Diet Database) and two indices (North Pacific Seabird Population Trend Index and the North Pacific Seabird Productivity Index). We will add the North Pacific Pelagic Seabird Database Version 2 once it is available. These databases and indices use a Google Maps<sup>®</sup> interface to display information to the public (front-end). Upon request, a user name and password is assigned to a data contributor and permits access to the on-line data entry application (back-end). Contributors may use the databases to archive their data, choosing one of three data release codes (unrestricted, restricted, and provisional) to determine how data would be disseminated during data download requests. The indices allow seabird researchers to quickly share preliminary results on population trends (over a 10-year period) and seabird productivity (relative to long-term average at the colony) and uses a red circle (declining population trend/poor productivity), amber circle (stable population trend/moderate productivity), or green circle (increasing population trend/good productivity) at a colony location. The North Pacific Seabird Data Portal provides the tools needed by today's seabird researchers to archive both legacy and contemporary seabird data while also sharing information with other scientists and the general public.

## YEAR-ROUND FORAGING DISTRIBUTION OF WEDGE-TAILED SHEARWATERS OF THE WESTERN INDIAN OCEAN

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We studied the year-round movements of wedge-tailed shearwaters (*Puffinus pacificus*) at a regional scale in the western Indian Ocean as part of a larger study aimed at identifying multi-species oceanic hotspots of biodiversity, and ultimately, target areas for designation as pelagic marine protected areas (MPAs). We deployed geolocation tags ( $n \geq 24$ ) on individuals at three breeding locations (St Joseph Atoll and Cousin Island, Seychelles, and Réunion Island) during the same year in order to compare the foraging distribution of individuals from each location concurrently. We sought to investigate whether or not different breeding populations have similar foraging distributions during both the breeding and non-breeding periods. Preliminary analyses have revealed that wedge-tailed shearwaters use marine habitats in close proximity to their respective colonies during the breeding period, and then migrate to a region of the central Indian Ocean south of India and east of the Chagos Archipelago during the non-breeding period. These data will be combined with tracking data from other seabird species, and resulting analyses will be presented to national and international agencies to aid in the identification of oceanic MPAs in the western Indian Ocean.

## TROPICAL SEABIRDS: INTERACTION, VARIABILITY AND MANAGEMENT STRUCTURES WITHIN THE BIRDLIFE IMPORTANT BIRD AREA (IBA) PROCESS

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In an effort to extend protection into the marine environment from terrestrial important bird areas triggered by seabirds, BirdLife International and their partners have developed a series of protocols and criteria for identifying and delineating important marine habitats of seabirds. Central to this effort has been the development of the seabird foraging database (<http://seabird.wikispaces.com/>), which serves to collate, summarize, and identify current knowledge gaps in the foraging ecology (e.g. foraging ranges, behaviors and associations, diet, dive depths) of the world's seabirds. A recent attempt to apply these protocols to seabirds breeding on the French administered Îles Éparses (The Scattered Islands), western Indian Ocean, revealed several life history characteristics of tropical seabirds that present challenges to implementing these protocols. In particular, the relaxed breeding (e.g. bi-annual, year round/opportunistic) and subsurface facilitated foraging behaviors of many tropical seabirds create unique challenges when attempting to identify and delineate important marine areas for protection. Recent advances in tagging technology have produced high quality data for some species, but rarely cover more than a couple of seasons and have seldom been overlaid with high quality movement data of subsurface predators in order to identify key foraging areas. Multi-season tracking efforts, tracking of smaller species and the integration of data on seasonal and localized movements of subsurface predators will help to address these knowledge gaps. However, the designation and protection of important marine habitats and areas for tropical seabirds may require managers to develop different protection criteria than those commonly employed for temperate species.

## DEEP DIVING DOVEKIES IN THE WARMING GREENLAND SEA

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The Atlantic sector of the Arctic is undergoing widespread climate change with increases in air and sea temperatures which impact the timing of ice retreat, snow melt and the development of the marine food web. We hypothesized that in the Greenland Sea, dovekies (*Alle alle*) breeding adjacent to water masses with smaller, less energy-rich prey, work harder to find food and have higher stress levels. We tested this hypothesis by attaching time-depth recorders to provisioning dovekies at three colonies adjacent to different water masses (the West Spitsbergen Current with the smallest prey, the East Greenland Current with the most lipid rich prey, and the Sorkapp Current which has a medium sized copepod). We determined the length of time dovekies at different colonies spent at-sea collecting food for themselves and their chicks. We also measured circulating corticosteroid hormone levels in their blood to assess stress levels. We collected chick meals to determine the energetic content of prey fed chicks at the different colonies. We found that dovekies are sensitive to the quality of prey available to them. Dovekies exposed to less profitable prey made longer foraging trips and worked harder while at-sea to collect prey for themselves and their chicks. We use this inter-colony comparison of dovekie foraging behavior as a model to understand how continued warming in the Greenland Sea may influence this species. Future declines in dovekies may impact terrestrial Arctic food webs which are highly influenced by the annual input of nitrogen-rich dovekie guano on the tundra.

#### EFFECTIVENESS OF DOUBLE-WEIGHTED BRANCHLINES FOR REDUCING ON SEABIRD BYCATCH IN PELAGIC LONGLINE FISHERIES OFF CHILE

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Double-weighted branchlines, which are consisted two leads placed at either end of a 1.5 m section of wire, are more safety mitigation measure compared with single-weighted branchlines. This mitigation measure demonstrates a high effectiveness to reduce seabird bycatch in the South Africa EEZ where diving seabirds caused many bycatch. However, the effect of double-weighted branchlines may be changed by seabird species and oceanic condition. In this study, we investigated what kind of species attacked baits and how many attacks occurred during line settings, and compared the number of bait attacks and the bycatch rates of double-weighted branchlines with those of un-weighted branchlines. Our study was carried out in a pelagic longline vessel off Chile during July and August 2011. A hybrid streamer tori-line on the portside of the stern deck was deployed every line setting. Double-weighted and un-weighted branchlines were alternatively deployed every 100 hooks. Wandering and black-browed albatrosses, and white-chinned, westland, grey and cape petrels were major seabird species that followed the vessel and these four petrels aggressively attacked baits. Many attacking by cape petrel categorized as surface feeder was observed in this survey. Weighted branchlines protected baits from the seabird attacks more effectively than un-weighted branchlines and the bycatch rate became lower. Although the bait attacks by diving seabirds occurred in Chilean water similar with South Africa EEZ, double-weighted branchlines demonstrated the high performance for reducing seabird bycatch in this study.

## EFFECTS OF SEABIRD-DERIVED NUTRIENTS ON NEARSHORE AQUATIC SYSTEMS AT THE COLONY OF BLACK-TAILED GULLS

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Seabirds input large amount of offshore-derived nutrients as a fecal into the terrestrial or nearshore aquatic ecosystem at the breeding colony. It is well known that nutrients input by seabirds strongly affect species richness and biomass of the terrestrial organisms. On the other hands, the description of the effect of such nutrients input on the nearshore aquatic ecosystems is relatively poor. Biomass of phytoplankton, and proportion of nitrogen content (N%) and nitrogen stable isotope ratio ( $\delta^{15}\text{N}\text{‰}$ ) of seaweeds, sea grass, and gastropods near the beeding colony of Black-tailed Gulls (*Larus crassirostris*) were measured and compared with those outside of the colony in Rishiri Island, Japan. Phytoplankton biomass near the colony was larger than that outside of the colony. Both seaweeds (*Laminaria*, *Enteromorpha*, *Sargassum*, *Gloiopeltis* etc.) and sea grass (*Zostera*) near the colony represented higher N% than that outside of the colony. Either the seaweeds, sea grass, or gastropods (*Littorina* and *Neptunea*) near the colony represented higher  $\delta^{15}\text{N}$  (10-14‰, similar value of the fecal) than that outside of the colony. These results indicated that seabirds-derived nitrogen could affect biomass and nutrient compositions of the organisms, one of potential factors affecting growth, mortality, and reproduction, at nearshore aquatic ecosystems, as well as terrestrial ones.

## IDENTIFYING NESTING HABITAT OF BRACHYRAMPHUS MURRELETS: OLD NESTS LEAD TO A NEW BREEDING RECORD

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The Kittlitz's murrelet (*Brachyramphus brevirostris*) is one of the least known seabirds in North America. To date, 87 nests (44% of the world's known nests) have been monitored at Agattu Island in the western Aleutians. In 2009, we noted that nests from previous years had dense vegetation (grasses and/or mosses) directly in and around the nest scrape, owing to nitrogen rich fecal material deposited by the nestling. Using these cues, we searched for 'non-active' nests, defined as nests used in previous breeding seasons but not monitored during our research efforts. Breeding use at non-active nests was confirmed by the presence of eggshell fragments, chick remains, and/or a fecal ring. At Agattu, 74 non-active nests were found between 2009-2011. To examine the broader application of using vegetative cues to identify nesting habitat, we searched habitat at Adak Island, located in the central Aleutians, during July and September 2010 and September 2011. Two non-active nests were located in 2010. In 2011, one non-active and three active nests (1 abandoned egg, 2 fecal rings) were discovered. We provide the first breeding record of a *Brachyramphus* murrelet nesting at Adak Island and confirm the utility of using non-active nests. This tool has great potential for identifying the breeding range of murrelets at other Aleutian islands and possibly throughout this species range.



## STATISTICAL MODELING OF SEABIRD DISTRIBUTIONS TO SUPPORT MARINE SPATIAL PLANNING

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Seabirds are highly mobile organisms that range widely and respond to dynamic features in their physical and biological environment at time scales from minutes to years. Effective marine spatial planning requires maps that characterize both the persistent spatial features of seabird distribution and uncertainty in distributions. Traditional atlas-type maps do not meet these needs. Moving from scattered, heterogeneous historical seabird data to gap-free, high-resolution distribution maps at the relatively fine spatial scales (~1km horizontal resolution or better) needed for modern coastal and marine spatial planning is a formidable statistical challenge, partly because any discernible long-term average spatial patterns must be inferred from incomplete observations on a process with a tremendous amount of inherent variation. The NOAA Biogeography Branch has been developing statistical methods to address these issues and produce high-resolution maps of long-term patterns of seabird distribution with rigorous uncertainty assessment. Products include high-resolution single-species maps as well as maps of multi-species diversity and abundance hotspots, and a statistical framework that allows propagation of uncertainty throughout the management decision-making process. These maps have proved useful to marine spatial planning efforts in New York (NY) and the broader Mid-Atlantic, and are likely to be equally applicable to marine spatial planning for renewable energy siting in the Pacific.

## NEEDLE IN A HAYSTACK: LOCATING KITTLITZ'S MURRELET NESTS IN A GLACIAL LANDSCAPE

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The Kittlitz's murrelet (*Brachyramphus brevirostris*) is a secretive, solitary-nesting seabird endemic to coastal Alaska and Russia. During the breeding season, this species is most abundant in marine waters where tidewater glaciers discharge, yet few nests have been located in the adjacent, ice-dominated uplands. We radio-marked 167 Kittlitz's murrelets prior to breeding in Icy Bay, Alaska, 2007-2011, and relocated them regularly throughout the breeding season. We attempted to ground truth all inland signals (presumed nests) to verify nesting activity and fate and to measure habitat features; we used dataloggers to monitor inaccessible nests. We located 26 active and 3 inactive nests, but only 5 active nests were accessible; the majority (81%) was placed on ledges of steep, rocky cliffs usually surrounded by icefalls and glacier on all sides. All nest sites were placed in barren, non-vegetated (<1% cover) areas of mountains, hills, or glacial till. Mean nest elevation was 1037 m (SD=707; range=161-2555) and distance to sea via presumed flight path was 16.53 km (SD=14.54; range=0.61-44.53). Confirmed or inferred nest fate was 8 successful, 14 failed (including 2 renesters), and 4 unknown. None of the habitat variables measured was correlated with nest fate. Mortality of incubating adults and unstable terrain near nests were

the most common known causes of nest failure. We believe that nesting on cliffs or exposed rock surrounded by glacier is functionally equivalent to nesting on predator-free islands for seabirds; changes in glacial extent may reduce the availability of safe nest sites for Kittlitz's murrelets in glacial landscapes.

## PUFFINUS SHEARWATERS IN THE NORTHEASTERN GULF OF ALASKA, 2002-2011

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Seven species of *Puffinus* shearwaters occur in the marine waters of Alaska during the summer (May-August): Pink-footed (*P. creatopus*; rare), Great (*P. gravis*; accidental), Buller's (*P. bulleri*; rare), Sooty (*P. griseus*), Short-tailed (*P. tenuirostris*), Flesh-footed (*P. carneipes*; casual), and Manx (*P. puffinus*; casual) shearwaters. None of these species are known to breed in Alaska and therefore individuals are not bound to central foraging areas or breeding sites during the summer months when they tend to occur in Alaskan waters. Consequently, our knowledge of their distribution in Alaska is largely based on opportunistic sightings documented during boat-based surveys for other marine species or anecdotal observations by birders. We compiled sight records of *Puffinus* shearwaters observed during marine bird surveys and associated fieldwork from Kayak Island to Cross Sound, especially Icy Bay, in the northeastern Gulf of Alaska, 2002-2011. We observed six species of *Puffinus* shearwaters in our study area across all years. The Sooty Shearwater was predictably common and well-distributed in the nearshore waters of the outside coast. The Short-tailed Shearwater was comparatively less common with only a few observations annually. Surprisingly, we observed Manx Shearwaters somewhat regularly each year and, in some years, they were relatively common. Usually they occurred in small groups (<5 birds) and remained in the same area for several days/weeks. We photographed one Great Shearwater near Cape Fairweather and identified one Buller's Shearwater west of Yakutat Bay. We speculate that some species of *Puffinus* shearwaters, especially Manx, are less rare in Alaskan waters than previously considered.

## ESTIMATING DEMOGRAPHIC PARAMETERS TO UNDERSTAND TREND OF THE KITTLITZ'S MURRELET

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The Kittlitz's Murrelet (*Brachyramphus brevirostris*) is a rare seabird endemic to coastal Alaska and Russia that often occurs in glacially-influenced marine waters during the breeding season. Evidence of population declines coupled with recession of many of Alaska's tidewater glaciers prompted listing this species as a candidate to the U.S. Endangered Species Act. However, population trend estimates are variable and imprecise, and it is unclear whether the uncertainty reflects changes in demographic variability or movements of birds. We developed multistate models for this species to estimate survival, reproduction, and movements, using data from 167 radio-marked birds, relocated once every 1-3 days, during the breeding season in Icy Bay, Alaska, 2007-2011. Daily movements were extensive, with the probability of a bird moving out of the bay (0.20) similar to that of a bird moving into the bay (0.26). However, the daily probability of a bird completely leaving our study area was very low (0.016),

demonstrating that movement alone cannot explain the variability of population size and trend in our study area. Furthermore, the daily survival rate for a Kittlitz's Murrelet in Icy Bay was 0.997, extrapolating to a within-season survival rate of 0.84. Therefore, to maintain a stable population, 32% of the adult birds in this area need to reproduce successfully each year. Yet, annual nesting effort, based on radio-marked individuals, was ~14% and only 6% successfully fledged a single chick. Although range-wide trend estimates are variable, low adult survival with low reproductive success may substantiate uncertain declining trends of Kittlitz's Murrelets.

#### HISTORICAL ACCOUNT OF SHORT-TAILED ALBATROSSES AT MIDWAY ATOLL NATIONAL WILDLIFE REFUGE INCLUDING A SUCCESSFUL SOCIAL ATTRACTION PROJECT WHERE A CHICK SUCCESSFULLY FLEDGED DURING THE 2010-11 BREEDING SEASON.

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From 1859 to 1903 ship-wrecked sailors and feather harvesters decimated the wildlife at Midway Atoll, well before the first naturalists arrived in the early 1900s. Therefore, it is unknown how many breeding pairs of short-tailed albatrosses (*Phoebastria albatrus*) may have historically occurred on this atoll. Periodic ocean wash-over events and US Navy habitat alteration seem to have erased any fossil record that may have occurred. The first documented short-tailed albatross at Midway Atoll was a single individual in 1938. From that time period until 2007, one or two short-tailed albatrosses were observed in most years. Four birds were observed in 2008. The short-tailed albatross social attraction project was initiated at the onset of the 2000–01 breeding season. A total of 42 short-tailed albatross decoys (some supplied by Japanese researchers) and a solar powered calling system were placed on one of the three islands (Eastern) within the atoll in the vicinity of a 12-year old male which first arrived in 1999. Seven years later, a five-year old female arrived and paired with the male. During the second season (2008-09), their time together increased. By the third season (2009-10), they arrived at the colony together and built a nest. During the 2010-11 breeding season on November 16, the male was observed incubating a freshly laid egg which eventually hatched on January 14. The chick successfully fledged by June 17, marking the first time a short-tailed albatross chick has fledged outside of Japan in recorded history.

#### PROTOCOL FRAMEWORK FOR BASELINE AND EFFECTS MONITORING OF OCEAN RENEWABLE ENERGY: OFFSHORE WIND CASE STUDY

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The need for consistency in monitoring baseline and environmental effects of offshore renewable energy prompted the U.S. Bureau of Ocean Energy Management, Regulation and Enforcement, U.S. Department of Energy, and National Oceanic and Atmospheric Administration, through the National Ocean Partnership Program, to jointly conceive and fund our team to:

- 1) Prioritize environmental stressor-receptor issues so environmental baseline and effects monitoring protocols can be developed;

- 2) Develop a framework so parties can identify information needs and appropriate protocols for collecting environmental monitoring data for wave, tidal, and offshore wind projects; and
- 3) Demonstrate the use and applicability of the framework by applying it to three case studies that exemplify wave, tidal, and offshore wind projects.

Our team, led by Pacific Energy Ventures, included Pacific Northwest National Laboratories (for tidal energy), Oregon State University (for wave energy), SAIC, and NMFS. The team collaboratively developed the framework, and our scope was to apply the framework in a west coast offshore wind case study, focusing on seabirds, bats, sea turtles, and ecosystem interactions. We document where protocols have already been developed and used in Europe, the advantages and disadvantages of various protocols, and where there remain needs to develop monitoring protocols. The framework also includes steps to prioritize monitoring needs based on stressor-receptor interactions. The framework will be useful to parties seeking basic information about ocean renewable energy development and its possible environmental effects, and to persons or organizations heavily involved in ocean renewable energy planning, development, and permitting.

#### SEASONAL SPATIAL RELATIONSHIPS BETWEEN SEABIRDS AND THEIR PREY – A MOVEABLE FEAST IN THE SOUTHEASTERN BERING SEA

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Seabirds are central place foragers while breeding, and presumably disperse to replenish energy reserves prior to winter, but there are little data from the post-breeding season. We used vessel-based surveys to examine seasonal changes in predator-prey spatial relationships in the southeastern Bering Sea. We compared seabird (birds/km<sup>2</sup>) and prey (fish/nmi<sup>2</sup>) densities during summer (June-July) and fall (late August-October) of 2008-2010. Data were collected from 32,000 km of transects within a 400,000 km<sup>2</sup> study area and summarized over a 37x37 km grid. Prey included juvenile walleye pollock (*Theragra chalcogramma*) and Pacific cod (*Gadus macrocephalus*), other forage fishes, and euphausiids. Both seabirds and prey showed species-specific spatial patterns that were often consistent across years, although there were interannual differences. With the exception of shearwaters (*Puffinus spp*) and surface planktivores, seabird densities in pelagic waters were significantly higher in fall. In summer, most breeding bird species were concentrated around colonies or along the outer shelf break, but dispersed to the mid and inner shelf in the fall; this coincided with the fall distribution of capelin (*Mallotus villosus*) and juvenile herring (*Clupea pallasii*) in the north and inner shelf, and juvenile cod and pollock in the south. Shearwaters, which do not breed in Alaska, aggregated along the Alaska Peninsula where euphausiid abundance was high in summer, but they dispersed northward in fall. Results suggest that while nearshore waters and the outer shelf are critical in summer, the mid and inner shelf of the southeastern Bering Sea provide important pre-winter resources for seabirds.

## USING SATELLITE IMAGERY TO MONITOR NESTING SHORT-TAILED ALBATROSS

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Millions of short-tailed albatross (*Phoebastria albatrus*) once ranged throughout most of the North Pacific Ocean and Bering Sea, nesting on numerous islands throughout the North Pacific. Market hunting practices drove them to near extinction, and today natural nesting colonies for the endangered short-tailed albatross are known from only two locations: Torishima Island and the Senkaku Island group. While the nesting population on Torishima Island is monitored annually, sovereignty disputes have limited our ability to monitor nesting colonies on the Senkaku Islands. As an alternative to on-the-ground productivity monitoring, we are investigating the efficacy of using satellite imagery as a method to remotely monitor short-tailed albatross productivity. Short-tailed albatross are large birds (about 0.89 meters tall), and their adult plumage is highly contrasted with their nesting environment. Commercially available satellite imagery has a resolution of 0.5 meters, so based on the size of the bird and the potential for color contrast, satellite imagery may prove to be a viable technique when on-the-ground productivity surveys are impossible. Phase I of the study includes searching GeoEye/Digital Globe archives for imagery of Torishima Island and the Senkaku Islands during October through May to assess the potential for viewing short-tailed albatrosses on the nest. The technique will be validated by comparing counts from satellite imagery of Torishima Island during November with counts from concurrent efforts by Japanese researchers on the ground. Results presented will include an assessment of the efficacy of the method and preliminary productivity data from the Senkaku Islands.

## IT PAYS TO HAVE A GOOD DATA PLAN – MONITORING SEABIRD COLONIES USING SOLAR POWERED CAMERA SYSTEMS WITH REMOTE DATA ACCESS AND REAL-TIME VIDEO STREAMING.

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Caspian Terns (*Hydroprogne caspia*) are a piscivorous, colonial seabird that nests on open or sparsely vegetated substrates. Recent management actions by the US Army Corps of Engineers have reduced the available nesting habitat on East Sand Island in the Columbia River Estuary, while simultaneously creating alternative nesting islands in other historical breeding areas. We used commercially available security cameras from Qorvus Systems, Inc. to record and monitor the activities at Caspian Tern breeding colonies on these alternative nesting islands in Oregon and California. We used the video footage and live stream to document factors limiting colony development and nesting success, including predator presence, nest failure, or other colony disturbances. Our camera design uses a solar voltaic array and battery bank to power a D12 Mobotix IP camera, server, external backup drive, and wireless internet access via a 3G network. The lens configuration of this system is adaptable to specific focal requirements and, when paired with an infrared lighting source, allows for recording and transmission of high quality video data in real-time, 24 hours a day. This system also allows us to place a live stream of the colonies on a publicly available website, where stakeholders and the general public can view the daily activities of a charismatic seabird. In addition to our work with Caspian Terns, this system could be used to record the

activities and behaviors of a variety colonial seabird species and provide real-time video images to collaborators and an interested public.

## KITTLITZ'S MURRELETS NESTING IN UNGLACIATED ALPINE HABITAT ON KODIAK ISLAND, ALASKA: UNRAVELING PARTS OF THE MYSTERY

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Kittlitz's murrelet (*Brachyramphus brevirostris*) is a rare seabird that nests in remote mountainous terrain in coastal areas of Alaska and the Russian Far East. It is a species of conservation concern, and currently a priority species for listing under the U.S. Endangered Species Act. Limited available data indicate that nesting success and fledgling recruitment are low. To fill significant gaps in our knowledge of the species' breeding ecology, we studied Kittlitz's murrelets nesting on scree slopes in unglaciated alpine habitats in Kodiak National Wildlife Refuge, Alaska. We discovered 53 active Kittlitz's murrelet nests during 2008-2011, and placed remote cameras near 33 nests to elucidate aspects of parental care, chick diet and growth, and factors limiting nest success. Nests were situated on steep slopes with little vegetation, and most nests were at least 200 m from the nearest active nest. Five nest sites were reused in successive years, and inter-annual nest locations appeared clumped on the landscape, suggesting fidelity to nesting territories. Of all active nests, only 28 (53%) produced hatchlings and only nine (17%) produced fledglings, confirming low nesting success. Young fledged 22 to 27 days post-hatch, suggesting intense selection pressure to fledge early. Red fox depredation and chick mortality on the nest for unknown reasons accounted for approximately 86% of all failed nests. These results enable the U.S. Fish and Wildlife Service and other land management agencies in Alaska to identify potential nesting habitats and factors limiting reproductive success for this poorly-known candidate species.

## MIGRATION STRATEGIES OF SEABIRDS OF THE TROPICAL INDIAN OCEAN

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Bird migrations have always fascinated people and among them, seabird migrations are even more impressive because they generally involve hundreds of thousands of birds, which can transform, in a few days, a desert island or cliff into an incredibly densely populated rookery.

In recent years the mysteries of seabird migration are progressively being solved, thanks to the progress of biologging.

Broadly, the different cases studied so far can be classified into two different strategies: the “transequatorial migrants” and the “longitudinal migrants”. Transequatorial migrants are seabirds that breed in spring and summer in one hemisphere and then migrate to the other hemisphere thereby benefiting from an “endless summer”. The “longitudinal migrants” are seabirds that remain in the same hemisphere all year round but migrate longitudinally from one side of an ocean basin, to another. In most cases the destination of these migrations is one of the major upwellings that develop in the west coast of each continent.

However most of these studies have been conducted in the Atlantic and Pacific Oceans, and migration patterns of seabirds in the Indian Ocean are poorly documented. Furthermore most studies on seabird migrations have been conducted on polar and temperate species (which have strong environmental reasons to migrate) and very few concern tropical species. In my talk, I will present up-to-date results on seabird migration in the tropical Indian Ocean and will discuss these results in relation to the physical and biological specificities of the tropics in general and of the Indian Ocean in particular.

#### PELAGIC CORMORANT POPULATION STATUS: THE KNOWN AND UNKNOWN ALONG THE PACIFIC COAST

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Pelagic Cormorants (*Phalacrocorax pelagicus*) breed in small and scattered locations along the coast of North America from Alaska to Southern California. Anecdotal evidence indicates a possibly declining population. A citizen science project has been monitoring selected colonies in Northern California for three years and has documented dramatic annual and spatial variation in breeding success. In 2009 two monitored colonies consisting of 38 nests averaged 1.95 fledglings per pair. In 2010 these two colonies had 22 nests and averaged 1.2 fledglings per pair. In 2011 these colonies had 26 nests and averaged 1.4 fledglings per pair. In 2010 we added one site to our monitoring and in 2011 we added 5 additional sites to our monitoring. The 2011 colonies ranged from 0 (one colony from 2010 was unoccupied in 2011) to 18 nests and ranged in fledgling success from 1.2 to 2.4 fledglings per pair. One site added in 2011 had not been occupied during the previous two years. Discerning whether a decline is real will require a longer effort and a much broader geographic scope. The format of the citizen science monitoring that we have been using is potentially a viable way to increase this effort.

#### POPULATION GENETICS OF GALAPAGOS GREAT FRIGATEBIRDS (*FREGATA MINOR*) AND NAZCA BOOBIES (*SULA GRANTI*)



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Seabirds are considered highly mobile, able to fly great distances with few apparent barriers to dispersal. However, it is often the case that seabird populations show strong population differentiation despite their potential vagility, indicating that habitat preference, natal philopatry or mate choice may present non-geographic barriers to dispersal. We studied the population genetics of two resident Galapagos seabirds: the pan-tropical Great Frigatebird (*Fregata minor*) and the Nazca Booby, (*Sula granti*), that has a far more restricted range. Using 8 microsatellite loci and 3 mitochondrial genes per species and F-statistic and Bayesian analyses, we were able to understand patterns of gene flow throughout the Galapagos archipelago. We found significant  $F_{ST}$  values for nearly all pair-wise comparisons of Nazca Booby populations sampled from different islands and support for 3 genetic clusters. In contrast, we found only weak to no population differentiation between Great Frigatebird populations on different islands. The genetic structure of the Nazca Booby populations is most likely due to strong natal philopatry; most individuals breed within a few hundred meters from their natal nest site.

#### RESTORATION OF SEABIRDS ON SAN NICOLAS ISLAND BY ERADICATING FERAL CATS

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Located off the coast of southern California, U.S. Navy-owned San Nicolas Island (SNI) supports several threatened and endangered species and provides important nesting habitat for the western gull (*Larus occidentalis*) and Brandt's cormorant (*Phalacrocorax penicillatus*). After five years of planning, the Montrose Settlements Restoration Program and U.S. Navy, in partnership with Island Conservation and the Institute for Wildlife Studies, initiated in 2009 an intensive effort to remove feral cats (*Felis silvestris catus*) from SNI. The goal of this project is to restore seabird nesting habitat and protect native fauna. As part of this comprehensive program, the U.S. Fish and Wildlife Service and U.S. Navy entered into a Memorandum of Agreement with The Humane Society of the United States (HSUS). From January 2009 to June 2010, a total of 66 cats were removed from the island. Of these, 59 cats were removed from the island and transferred to the HSUS for permanent care at an enclosed facility in Ramona, CA. A mitigation program was put in place to reduce impacts to the endemic island fox related to the trapping effort. Cameras were deployed across this island to detect any remaining cats. Since the removal of the last cat in June of 2010, over 21,000 camera trap nights and 249 km of sign search has confirmed that feral cats are no longer present on SNI. Monitoring is ongoing to detect changes in seabird populations and endemic mammals and reptiles on SNI as a result of the removal of feral cats.

#### BRANDT'S CORMORANTS ON EAST SAND ISLAND: NEST NUMBERS, DIET, AND SPACE USE IN A MIXED SPECIES BREEDING COLONY

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Brandt's Cormorants (*Phalacrocorax penicillatus*) and Double-crested Cormorants (*P. auritus*) currently breed in a mixed-species colony on East Sand Island near the mouth of the Columbia River in Oregon. Brandt's Cormorants were first observed breeding on East Sand Island in 2006 within a large ground-nesting colony of Double-crested Cormorants established in the late 1980s. We used direct counts of active nests on high-resolution aerial photography during late incubation to determine the total number of breeding cormorants annually and a combination of blind-, boat-, and aircraft-based images and post-breeding nest structure inspections to map and enumerate Brandt's Cormorant nests. During 2006-2011, Brandt's Cormorant nesting on East Sand Island increased steadily from 44 to 1,491 breeding pairs, while Double-crested Cormorant numbers remained relatively stable (ca. 13,000 breeding pairs). After cormorants had dispersed from the colony, we used hand-held transceivers to detect salmonid passive integrated transponder (PIT) tags on the nesting areas of each species. PIT tags recovered during 2009-2010 indicated that consumption rates of PIT-tagged smolts (PIT tags consumed per breeding pair) were 0.24-0.26 for Brandt's Cormorants and 2.38-2.97 for Double-crested Cormorants. PIT tag recoveries support previous findings that the impact of Brandt's Cormorants on survival of salmonid smolts that pass through the Columbia River estuary is low relative to the impact of Double-crested Cormorants. Rapid growth of the East Sand Island Brandt's Cormorant colony, including use of breeding space formerly occupied by Double-crested Cormorants, suggests that Brandt's Cormorants are successfully competing for nesting habitat with their larger, more numerous congener.

## MARINE BIRD "HOTZONES" IN THE CALIFORNIA CURRENT

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The highly productive but variable California Current Ecosystem (CCE) supports millions of resident and migratory seabirds distributed heterogeneously over time and space. Distribution and abundance are influenced by static and dynamic physical conditions and biological oceanography. We developed and applied a kernel density smoothing approach to identify persistent at-sea hotspots of abundance for 28 species of seabirds based on long-term (1987-present) at-sea observations from the California Cooperative Oceanic Fisheries Investigation (CalCOFI), NMFS Juvenile Rockfish Survey (JRS), Line P, and other data contained in the North Pacific Pelagic Seabird Database (NPPSD). We created distribution maps for common species and species of conservation concern. Typically, each hotspot was defined by only 1-5 species, so to obtain information on important areas for entire seabird communities, we aggregated hotspots. By grouping species-specific hotspots, we established 4 major seabird "hotzones" in the CCE, including the North Vancouver Island, Olympic Coast, Greater Gulf of the Farallones, and Santa Barbara Basin. Each of these zones contained at least one relatively large, diverse breeding colony, and showed differences in migrant community structure. In addition to colonies, hotzones were, as expected, associated with the presence of shallow-water topographies (seamounts), bathymetric variation (canyons), and freshwater input which may have created oceanographic structures such as fronts. Seabird "hotzones" may be useful in defining marine Important Bird Areas (mIBA), and may also play an important role in marine spatial planning, such as siting of offshore energy devices, fisheries management, and other considerations.

## ACCOUNTING FOR YEARLY VARIATION IN ALBATROSS BYCATCH IN THE DEEP-SET HAWAII PELAGIC LONGLINE FISHERY

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Incidental catch of protected seabirds is a major issue in commercial fisheries across the world. Because the scope of interactions between fisheries and seabirds may directly influence fisheries management measures (fishing limits, seasons, etc.), it is important to understand what factors influence variation in seabird bycatch. The Hawaii pelagic deep-set longline fishery has interactions (hookings/entanglements) with two and potentially three species of protected albatross (black-footed (*Phoebastria nigripes*), Laysan (*P. immutabilis*), short-tailed (*P. albatrus*)). To monitor these interactions, observers were placed (randomly) aboard 20% of these trips. Observers recorded catch composition of target and bycatch species, as well as sightings of seabirds and protected species. Since mitigation measures to reduce seabird bycatch were introduced in 2003, yearly variation in dead albatross observed captured has ranged from 6 (0.001 albatross/1000 hooks set -2004) to 55 (0.007/1000hks -2010). Factors including fishing location, fishing effort, mitigation effort, and number of albatross sighted during fishing effort were examined to determine effect on albatross bycatch. Season and number of albatross sighted during fishing effort were highly associated with albatross captured. Certain areas were highly associated with albatross presence, but area alone did not predict albatross bycatch. Variation in mitigation strategies had no noticeable impact on bycatch. By determining factors that trigger increased seabird bycatch, strategies can be implemented to further reduce the impact of fisheries on albatross populations. The success of observer data in revealing patterns in protected species encounters has been paramount in reducing seabird bycatch, and may be utilized to further reduce these interactions.

## ASSESSING PLASTIC INGESTION AND DIET OF WEDGE TAILED-SHEARWATERS (*PUFFINUS PACIFICUS*): TOWARDS A METRIC OF MARINE DEBRIS AROUND OAHU

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Wedge-tailed Shearwater chicks were salvaged from Oahu, Hawai'i to quantify plastic ingestion in relation to condition and diet. Necropsies were performed on 143 chicks (70 from 2009, 73 from 2010) to quantify morphometrics, plumage, condition, health, and stomach contents. Principal Components Analysis quantified the relationships amongst these variables using two axes, which explained 98.9% of the variation. Percent of down (indicative of age) had the strongest loading on PC1, whereas body condition (fat score) and weight loaded most strongly on PC2. Plastic and squid occurrence were correlated with both PC axes. Detailed analyses of proventriculus and gizzard contents on a subset of 50

birds (25 per year) revealed that 78% of shearwaters contained plastic. While all six plastic types were documented, fragments constituted the largest proportion, followed by line and sheet, and trace amounts of foam and pellets. Plastic incidence and loads were higher in the proventriculus than the gizzard ( $p < 0.005$ ), without differences across years. Birds with plastic contained an average of 2.9 fragments (mean weight 0.033g) in the gizzard. The average number of fragments in the proventriculus was 4.1 (mean weight 0.106g); one bird contained 42 fragments. The amount of plastic in both the gizzard and the proventriculus were negatively correlated with the number of squid beaks in the gizzard ( $p < 0.05$ ). While all birds contained squid beaks, numbers were higher in 2009 ( $p < 0.001$ ). Their high incidence of ingested plastic and their restricted foraging range highlight the value of Wedge-tailed Shearwaters as bio-indicators of marine debris around breeding colonies.

## EVALUATING BENEFITS TO ESA-LISTED SALMONID POPULATIONS FROM REDUCTIONS IN AVIAN PREDATION IN THE COLUMBIA RIVER BASIN

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Management of Caspian terns (*Hydroprogne caspia*) in the Columbia River Estuary has been ongoing since 1999 to reduce predation on juvenile salmonids (*Oncorhynchus* spp.), many populations of which are listed under the U.S. Endangered Species Act (ESA). Resource managers are now evaluating if management to reduce predation by other colonies of piscivorous waterbirds in the basin would also be appropriate to benefit listed salmonids. Towards this end, we estimated the potential benefits to salmonid populations using a deterministic, age-structured, salmonid population growth model framework. We performed this analysis for reductions in predation by the East Sand Island double-crested cormorant (*Phalacrocorax auritus*) colony in the Columbia River estuary (ca. 13,000 breeding pairs), and for five colonies in the interior basin consisting of Caspian terns (850 pairs), double-crested cormorants (325 pairs), and ring-billed and California gulls (*Larus delawarensis* and *L. californicus*; 3,350 pairs combined). The greatest potential benefit from a reduction in predation by birds from a single colony was for the Upper Columbia River steelhead population if predation were reduced by Caspian terns nesting at Potholes Reservoir in eastern Washington, where a potential 3.7% increase in the average annual population growth rate ( $\lambda$ ) could be achieved if predation were completely eliminated and the reductions in predation were not compensated for by other mortality factors. Our analysis indicates that further actions to reduce avian predation on juvenile salmonids in the Columbia Basin will not by themselves recover any ESA-listed salmonid population, but would be comparable to some other salmon recovery efforts.

## POST-BREEDING MOVEMENTS OF KITTLITZ'S MURRELET FROM THE GULF OF ALASKA AND ALEUTIAN ISLANDS TO THE ARCTIC

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Kittlitz's Murrelet (KIMU) is a rare seabird that nests in the coastal mountains of Alaska and often forages in glacially-influenced marine waters during summer. This species is of significant conservation concern, yet little is known about their post-breeding migration patterns and factors affecting them in their wintering habitat. We used solar-powered satellite transmitters (PTTs) to track 31 birds that were captured at four Gulf of Alaska (GOA) sites (Icy Bay, Glacier Bay, Prince William Sound, Kachemak Bay), and a single Aleutian Island (Atka Island) in 2009-2011. KIMU tagged in the GOA moved westward to the Alaska Peninsula after the breeding season. Three birds tagged in Prince William Sound moved further into the Bering Sea and then north into the southern Beaufort Sea. Two birds tagged at Atka Island crossed the shelf edge in the Bering Sea toward the Pribilof Islands and Nunivak Island. Among the three years, KIMU followed similar migratory pathways, but timing and endpoints differed, in part due to transmitter retention. Migrating birds typically traveled long distances in a short time, sometimes flying over land and at speeds of up to 85 km/hr. Post-breeding foraging locations were identified in lower Cook Inlet, southwest Kodiak Island, Port Heiden, and Point Lay. We speculate that KIMU observed during at-sea surveys along the ice edge during winter in the northern Bering Sea may include birds that migrate from the GOA in fall, perhaps reflecting a migration strategy that exploits productive glacial-marine waters in summer and productive sea ice-edge habitat in winter.

#### HETEROSPECIFIC COURTSHIP IN HIGH ARCTIC ROSS'S GULLS: THE ROLE OF SURROGATES IN SEXUAL DISPLAY

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Heterospecific sexual displays are notable because they should be strongly deterred by natural and sexual selection *per se*. Although such behavior has not been previously documented as a routine tactic in any species, it is theoretically possible that deliberately directed heterospecific displays may increase individual fitness under specific conditions. Here we report that High Arctic breeding Ross's Gulls (*Rhodostethia rosea*) routinely engage in sexual display and courtship directed towards Black-legged Kittiwakes (*Rissa tridactyla*). We suggest that in small, male-biased populations, morphologically similar species may serve as surrogates in stereotyped sexual displays advertising fitness and experience to both male and female conspecifics. Heterospecific displays may serve to establish a dominance hierarchy among male Ross's Gulls, and reflect an adaptive strategy to compress the reproductive cycle in response to a brief and highly variable Arctic breeding season. This previously undescribed behavior offers insights into the evolution of intrasexual courtship and lek mating systems.

#### ESTIMATING COLONY AND BREEDING POPULATION SIZE FOR NOCTURNAL BURROW-NESTING SEABIRDS

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Estimating colony areas, locations, population sizes, and trends, are all important aspects of managing animal populations. The ability to assess population trends and delineate important wildlife areas remains a top priority for managers and conservation biologists. Yet, outdated labourious estimation methods remain in high use. By simulating known populations on known island sizes and using established transect and quadrat survey methods we asked whether using inverse distance weighting (IDW) interpolations in ArcGIS provide improved estimates of colony area and population size for nocturnal burrow-nesting seabirds over conventional global interpolation methods. We performed 100 simulations for each of three population sizes (500, 1000, and 50 000 breeding pairs) on three island sizes (10 ha, 50 ha, and 500 ha), excluding the largest population size on the smallest island size, for a total of 800 simulated islands. We estimated colony area and population size for each simulated island using both IDW interpolations and an established global interpolation method. Accuracy of each estimate was then calculated and using an information theoretic approach we found that IDW interpolation estimates were overall more accurate in all cases except when colonies were clustered, where there was no difference in colony area accuracy between interpolation methods. We recommend using IDW interpolations to estimate colony area and population size along with consistency in survey structure both among study sites and years. We also recommend maintaining a consistent transect length whenever possible to ensure observer bias do not influence areas surveyed.

#### CRUISE SHIP DISTURBANCE TO KITTLITZ'S MURRELETS (*BRACHYRAMPHUS BREVIOSTRIS*) IN GLACIER BAY NATIONAL PARK AND PRESERVE, ALASKA

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The Kittlitz's Murrelet (*Brachyramphus brevirostris*) is a small, rare Alcid that occurs across much of coastal Alaska and parts of the Russian Far East. A recent population decline across their range prompted the U.S. Fish and Wildlife Service to categorize the species as a candidate for listing under the Endangered Species Act. In advance of this decision we have initiated research into the magnitude of disturbance by cruise ships to Kittlitz's Murrelets in Glacier Bay National Park (GBNP) during the breeding season. During breeding, an estimated 15-20% of the world's population occurs in GBNP. Under current regulations, up to two cruise ships per day enter Park waters in the summer months. To quantify the magnitude of response to cruise ships traveling within GBNP, we are using land-based and cruise ship-based observation methods. Land-based observers collect before, during, and after disturbance time-activity data to measure effects of ships, both temporally and spatially, on this component of behavior. Ship-based observers, using range-finder binoculars and digital voice recorders, measure how vessel speed, size, and distance are associated with the magnitude of response by Kittlitz's Murrelets to cruise ships as they traverse the Park. Kittlitz's Murrelets were observed flushing in advance of cruise ships at distances of 106-626 meters. A Cox Proportional Hazards Model is being developed to determine how cruise ship variables are related to the magnitude of disturbance. With model output, we aim to

provide managers with practical suggestions on ways to limit cruise ship disturbance to Kittlitz's Murrelet within the Park.

## COMPARING COMMON AND THICK-BILLED MURRE NONBREEDING HABITAT WITH STABLE ISOTOPES CONFIRMS VARIATION IN MOVEMENT STRATEGIES.

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Congeneric Common and Thick-billed Murres in the NW Atlantic share partially overlapping distributions. Dietary niche partitioning is apparent during breeding, Common Murres (*Uria aalge*) consuming predominantly schooling fishes and Thick-billed Murres (*Uria lomvia*) a wider variety of fish and invertebrates, with some seasonal variation in diets. Within species, inter-colony dietary differences reflect spatial differences in colony foraging location. Outside the breeding season, stable isotope and stomach content analyses have indicated variation and seasonal shifts in dietary composition within and between species. Comparative studies of murre species' nonbreeding diets would be greatly enhanced by knowing respective patterns of habitat use. Similar to patterns during breeding, we propose that patterns of nonbreeding habitat use drive inter- and intra-specific trophic connections. We compare isotope ratios of feathers and nonbreeding distributions to illustrate variation in nonbreeding movement strategies. We hypothesize that 1) trophic similarity between groups increases with spatiotemporal overlap of overwintering habitat (i.e., birds wintering in similar areas eat similar prey); and (2) similar groups (i.e. species, colonies, or sexes) will have greater trophic similarity. We used geolocators to identify nonbreeding areas of Common and Thick billed Murres originating from 7 colonies spanning 47°- 79°N and collected blood (breeding), flight feathers (post-breeding) and body feathers (pre-breeding) for comparative analyses. Preliminary results confirm greater variation in murre isotopic signatures as spatial distributions diverge. Consistent patterns of carbon depletion occur during nonbreeding for both species, apparently in keeping with offshore movement; however, patterns of nitrogen enrichment vary by species and colony.

## SEABIRD HOT SPOTS IN CENTRAL CALIFORNIA'S NATIONAL MARINE SANCTUARIES AND THEIR IMPLICATIONS FOR OIL SPILL RESPONSE PREPARADNESS AND MARINE SPATIAL PLANNING

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Oil-related incidents from industrial shipping are one of the most significant threats to marine wildlife in the Cordell Bank and Gulf of Farallones National Marine Sanctuaries. The goal of this study is to identify predictable foraging habitats used by resident species of marine bird to inform oil spill response



preparedness and improve ocean zoning thus contributing to new marine spatial planning efforts in central California. We used data collected during the Applied California Current Ecosystem Studies (ACCESS, [www.accessoceans.org](http://www.accessoceans.org)) cruises conducted by PRBO Conservation Science, Cordell Bank and Gulf of the Farallones National Marine Sanctuaries from 2004 to 2010. Marine bird data were collected using standardized strip transect survey methods and binned at 3-km intervals. Hydrographic data were collected continuously using a thermosalinograph equipped with a fluorometer and averaged to single values that matched the 3-km bins used for birds. Bathymetric data were extracted using a Geographic Information System for each 3-km bin. We modeled the distribution and abundance of resident marine birds relative to bathymetry and hydrography using negative binomial regression. We used models to predict preferred foraging habitat within the study area. Preferred foraging habitat raster surfaces were combined using MARXAN to identify hotspots for each species and across species. We present preliminary results that show the value of these analytical approaches to improve marine conservation in central California.

## A WIRELESS SENSOR NETWORK FOR DETECTING AND MONITORING RARE AND ELUSIVE SEABIRD SPECIES

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Seabirds are the most threatened marine group with nearly 28% of extant seabird species considered at risk of extinction. Managers and researchers face considerable financial and logistical challenges when designing programs to monitor and study the 49 Critically Endangered/Endangered seabird species because they breed in isolated/inaccessible locations and because 26 of them return to concealed nest sites only at night. Acoustic sensors are a cost-effective tool that can minimize these constraints and help to document the presence, distribution and relative abundance of rare/elusive seabirds in remote locations. To date, sensors have been deployed successfully to monitor Hawaiian Petrel (*Pterodroma sandwichensis*), Newell's Shearwater (*Puffinus newelli*), Band-rumped Storm Petrel (*Oceanodroma castro*), Ashy Storm Petrel (*O. homochroa*), Marbled Murrelet (*Brachyramphus marmoratus*) and others. To be effective at scale, a comprehensive acoustic monitoring approach needs to be: a) low-cost; b) capable of telemetering data from remote locations over long deployment periods; and, c) integrated with an automated analyses process. We tested a pilot system with these capabilities on Southeast Farallon Island, CA a globally important seabird colony 27 miles from the mainland. The network was functional over the entire 78-day deployment and transmitting 99% of expected data despite dense fog, salt, humidity, and gulls. Analysis of recordings detected all 3 primary species of interest – Ashy Storm Petrel, Cassin's Auklet (*Ptychoramphus aleuticus*), and Rhinoceros Auklet (*Cerorhinca monocerata*). The success of this work makes it conceivable to design a comprehensive acoustic monitoring program for all of the world's Critically Endangered seabird species at island breeding sites.

## THE CIRCADIAN RHYTHM OF BREEDING CASSIN'S AUKLETS' DIVING BEHAVIOR DURING FORAGING TRIPS

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The purpose of this study was to investigate the circadian rhythms of Cassin's auklets' (*Ptychoramphus aleuticus*) diving behavior. We hypothesized that Cassin's auklets adjust their diving to the diel shifts in the vertical distribution of their euphausiid prey (*Euphausia pacifica* and *Thysanoessa spinifera*). We predicted that early morning and evening dives would be shallow and midday dives would be deep, reflecting the prey distribution in the water column. We tested this hypothesis by affixing Time Depth Recorders (TDRs) on breeding birds on Southeast Farallon Island. We affixed TDRs to 15 birds in 2010. We recorded temperature and depth during 2,940 dives. We found that Cassin's auklets depart the colony at 4:33am (+/- 4.07 min). In the morning, from 5am to 6:30am, they dive to shallow depths (mean maximum depth = 7.99m +/- 0.59m). During the middle part of the day when the sun is up (8am to 5:30pm) they forage deeper (mean maximum depth = 14.13m +/- 0.16m). From 6:30pm to 9pm, Cassin's auklets forage at slightly shallower depths (mean maximum depth = 12.75m +/- 0.18m). They return to the colony at 22:05 (+/- 12.25 min). It was previously unknown whether Cassin's Auklets forage throughout the middle part of the day. We found that the Cassin's auklet are able to adjust their dive depths to be able to target deeper prey. The maximum dive depth we recorded was 39.93m, however, most dives were not this deep.

#### BEST-PRACTICE SEABIRD BYCATCH MITIGATION FOR PELAGIC LONGLINE FISHERIES

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Although tori lines are the most widely prescribed seabird mitigation tool in longline fisheries, the lack of research evaluating the merits of competing tori line designs and how they are deployed frustrate progress toward required seabird mitigation in pelagic longline fisheries. In prelude to large scale controlled experiments in high interaction (worst case) pelagic fisheries in 2009, daylight observations were made aboard two Japanese fishing vessels typical of high-seas RFMO fisheries - one in the New Zealand EEZ and one outside the South Africa EEZ. In both fisheries, vessels used two tori lines with streamers and deployed baits via a bait casting machine, which delivered baits well beyond the protection of both tori lines. Also the first streamer of the tori line on each vessel was 20 to 35 m astern leaving a large unprotected area where birds could intercept baits. In the New Zealand fishery this led to the mortality of 21 birds in just 138 minutes and bait loss of 16%. In the South Africa fishery no birds attacked baits in this unprotected area and only one bird was killed in 14 sets. Trials of assorted methods to create drag and maximize the aerial extent of tori lines were frustrated by frequent fouling of longline floats, the weak nature of tori poles, and the tensile strength of the tori line itself. Ultimately, an optimal tori line design was conceived that fuses design elements from the Alaska demersal fishery and the Japanese "light line". Continued collaboration with Japanese Fishing Masters, vessel owners, permit holders and fishery managers will result in important innovations and definitive tests in 2009.

## BLACK SKIMMERS (*RYNCHOPS NIGER*) IN AN URBAN LANDSCAPE: CONTAMINANT AND DIET INFLUENCES ON REPRODUCTIVE OUTPUT IN SAN DIEGO BAY

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Southern California's fragmented coastal wetlands provide essential nesting and foraging habitat for over 300 bird species, including the Black Skimmer (*Rynchops niger*). Persistent organic pollutants (POPs), including anthropogenic organohalogen compounds like polychlorinated biphenyls (PCBs) and polybrominated diphenyl ethers (PBDEs), occur throughout southern California's waterways and are known causes of reproductive and physiological impairments in wildlife. Despite the importance of fragmented estuarine habitats like San Diego Bay and Tijuana River Estuary, these areas often contain high levels of contaminants from urban runoff. Emerging research is addressing the bioaccumulative implications of halogenated natural products (HNPs) - naturally occurring compounds that mimic synthetic POP counterparts - yet little is known about their presence and persistence in coastal species. By analyzing non-targeted HNPs in conjunction with targeted POPs, we can comprehensively assess contaminants present and the true toxin burdens to wildlife.

Throughout the US, Black Skimmers exhibit poor reproductive success. Previous studies show that skimmers accumulate contaminants in higher amounts than similar piscivorous seabirds, possibly because they forage along coastal wetland margins susceptible to high concentrations of runoff. The broad goal of this project is to quantify maternal transfer of nutrients and contaminants to eggs and chicks. To determine effects of diet and contaminants on reproduction, we analyzed viable and non-viable eggs and adult blood and tissue samples of trapped skimmers for POPs, HNPs, and nitrogen and carbon stable isotopes. Here I present preliminary results of these analyses, indicating differential maternal trophic and contaminant transfer to eggs and the implications for reproductive output.

## CONNECTING SYSTEMS: CAN SHARED SENSITIVITIES TO ENVIRONMENTAL VARIATION BE USED IN HINDCASTING APPLICATIONS FOR THREATENED SPECIES?

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To some extent, marine predators of eastern Pacific Ocean upwelling ecosystems should show shared sensitivities and responses to temporal environmental (e.g., coupled oceanic-atmospheric) variability. We used two representative seabirds, one from the California Current and the other from the Humboldt Current ecosystem, to test this hypothesis. In addition, we examine how co-variation, if established could be used in hind-casting population change for one of the species, which is endangered, but for which data are lacking. We selected the Brandt's Cormorant (*Phalacrocorax penicillatus*) of the California Current as a species with well-studied demography and compared its sensitivity to environmental variability to that of the endangered Galápagos Penguin (*Spheniscus mendiculus*), for which there is limited information and data to make management decisions. Despite one species inhabiting the temperate California Current and the other a tropical region, these species showed a high degree of co-variation in

available demographic measurements and shared sensitivities to a basic-scale environmental measurement, the Oceanic Niño Index (ONI). We then used reproductive success of Brandt's Cormorant (1973-2007) to hindcast the annual percent population change of the Galápagos Penguin to obtain a complete dataset for this key demographic measurement. We suggest that the study of population dynamics of small, threatened seabird populations can be enhanced by examining co-variation between species and physical oceanographic attributes, even when using information from apparently disparate ecosystems.

## POST-RELEASE MONITORING OF WESTERN GREBES USING IMPLANTED SATELLITE TRANSMITTERS

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Western grebes are in decline along the western coast of the United States and often are impacted by oil spills and natural seeps when wintering along the Pacific coast. There is a dearth of information regarding the efficacy of post-oil spill rehabilitation and the evaluation of rehabilitated grebes post-release has been prevented by a lack of suitable tracking capability. This study was designed to answer several questions including: 1) can satellite transmitters be implanted successfully in Western grebes, 2) how long do the grebes survive post-release, and 3) what are their wintering and migrating patterns? Previous work resulted in a modified surgical technique to implant this species with satellite transmitters. In this next phase of the research, we used this modified technique to implant satellite transmitters in 10 Western grebes captured in early December 2010 in San Francisco Bay, California. Nine of ten birds survived surgery and were released. Post-release, all birds survived at least 25 days suggesting a lack of complications related to surgery. After 25 days, survival showed a steady decline and currently only two grebes are still transmitting. One bird did not migrate, while the other migrated to Upper Klamath Lake in Oregon in July and recently returned to San Francisco Bay in November 2011. This is the first study to document winter site fidelity and migration of a Western grebe from its marine wintering ground to an inland breeding colony and back. It provides the first step for developing a safe technique for using intracoelomic satellite transmitters for post-oil spill tracking of Western grebes.

## DEVELOPMENT OF VISUAL ACUITY IN LEACH'S STORM PETRELS

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Procellariiform seabirds wander the world's oceans to forage and bring food back to juveniles. Foraging strategy models define that in the visually featureless open oceans olfactory cues guide

seabirds to the feeding grounds. However, once in place, birds have to rely on vision to capture the prey. Leach's storm petrels (*Oceanodroma leucorhoa*) spend several days offshore before coming back to the colony at night where they have to find their own burrow in a cluttered forest environment. While their olfaction is relatively well studied, nothing is known about the visual system of these birds. Using behavioural and anatomical methods we investigated how visual acuity in dim light develops as Leach's storm petrel juveniles grow from hatchlings to fledglings. Even though the retinal image brightness determined anatomically does not differ significantly between chicks of two, four and six weeks post hatching, two week olds showed no response in negative phototaxis experiments, inferring vision is not yet functioning at his age. Four weeks old juveniles were able to see visual stimuli of 0,5 cycles/degree and chicks of six weeks of age were able to discriminate stimuli of 1 cycle/degree at light levels corresponding to civil twilight. No response was observed in even darker light conditions. The maximum anatomical spatial resolution of fledglings was found to be 6 cycles/degree, which corresponds to the visual acuity of chickens. Further investigation of adult Leach's storm petrels is needed to fully understand the development of visual properties guiding foraging and burrow finding behaviours.

#### HOW TELOMERE LENGTH CHANGES WITH AGE IN GULLS.

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Telomere length is shortened at every cell division, and cell division stops if telomere reaches a critical minimal length. Therefore, the length might be related to senescence. In the case of birds, however, the relationship between telomere length and age is inconsistent; in some cases, telomere length decreases in a linear or an exponential way as the age increases; in other cases, telomere length does not show any relationship with adult age, although it differs between chicks and adults. This may be occur because previous studies of telomere dynamics have not been examined at individual-level, but at population-level. In this study, we investigated the annual dynamics of telomere length in adult Black-tailed gulls (*Larus crassirostris*) by repeatedly sampling individuals of known-age during consecutive breeding seasons. As a result, telomere length of most individuals tended to decrease with age. However, it increased in older males with a different rate of change, which may decrease the telomere-age relationship in all Black-tailed gulls. In future work, it is necessary to investigate variability among cohort in the initial telomere length at fledging and relate biological and physiological information with telomere change within individual revealed by this study.

#### HAWAIIAN PETRELS AT SEA IN THE NORTHEAST PACIFIC: OCEANOGRAPHERS, METEOROLOGISTS OR BOTH?

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Recent remote tracking has shed light on the movements and at-sea distribution of Hawaiian Petrels (*Pterodroma sandwichensis*). Here we present the locations of 41 sightings of Hawaiian Petrels observed during vessel-based surveys in the northeast Pacific Ocean (defined as north of 40°N and east of 157°W), spanning 1984 through 2010. Within a portion of this region (49°N to 54°N, and 132°W to 148°W), we compiled hydrographic characteristics collected concurrently with the at-sea observations. We also examine meteorological conditions, in advance of and during the at-sea surveys, to explain the presence or absence of Hawaiian Petrels. Although undoubtedly influenced by survey timing, the petrels were observed between from early June to the third week of September.

Hawaiian Petrels appeared to respond to both atmospheric and oceanographic cues. This study is significant in providing a basis for modeling changes in distribution of this endangered species in relation to climate change in the northeast Pacific and other anthropogenic impacts.

#### METHODS FOR MANAGEMENT OF SEABIRDS AND TUNA: TEASING APART A COMPLEX INTERACTION IN A CHANGING OCEAN

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Subsurface predator facilitated foraging interactions between seabirds and tunas are thought to be a key foraging mechanism for many tropical seabird species. The ecological and mechanistic details of this interaction are poorly understood, however, making management measures that involve fostering this interaction difficult. In conjunction with NOAA Pacific Islands Regional Office, Marine Conservation Institute conducted an expert workshop looking at methods and approaches to the study and management of this interaction particularly in relation to the US Pacific Remote Islands Marine National Monument (PRIM). We focused on five key topics determined to be central to further understanding and management of seabird-tuna interactions: (1) foraging ranges of breeding seabirds, (2) distribution and behavior of subsurface predators, (3) diet studies of seabirds, (4) limiting factors for breeding performance, and (5) the level importance of this interaction to seabirds. A number of methods were identified as central to studying these topics including diet and isotope studies, tracking and tagging studies, and at-sea surveys. Participants further identified approaches for increasing scientific understanding and approaches for monitoring seabirds in the PRIM, including timetables and relative costs of research activities. This culminated in a detailed outline of the research needs for the PRIM. Through this presentation we hope to engage the larger seabird community in the research needs surrounding the PRIM and the larger topic of seabird-tuna interactions, as well as provide insights for managers of marine protected areas that are faced with managing pelagic ecosystems and highly mobile species.

## USE OF INFRARED THERMOGRAPHY IN OILED SEABIRD REHABILITATION

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We investigated a novel application of non-invasive infrared (IR) thermography to determine thermal balance and plumage integrity of seabirds during rehabilitation. During an oil spill response, there is a need to quickly move seabirds from pens to pools to prevent captivity-related foot and keel injuries. Regaining thermal balance post-wash is a critical first step for pelagic species; they must regain plumage waterproofing by re-aligning feathers and preening to prevent water from penetrating to the skin. The current practice of checking waterproofing requires frequent handling, is time and labor intensive, is stressful for birds, and disrupts the physical alignment of the feathers, which the birds must expend extra energy to re-align. We tested the use of the IR camera to assess post-wash waterproofing in oiled (n = 7), fouled (n = 2) and non-oiled/fouled (n = 5) seabirds at two rehabilitation centers. Thermographs were compared with traditional (physical) waterproofing assessments to assess the efficacy of IR thermography. Of 20 waterproof-checking sessions conducted, the handler's assessment of waterproofing and the interpretation waterproofing by analyzing the thermograph had a 76% agreement rate, a 24% disagreement rate, and in 3 cases there was no handler assessment accompanying the thermograph for comparison. Although thermography was effective for assessing ventral waterproofing, the heat signature may be compromised by some handling techniques, accounting for most of the discrepancies between the human and IR assessments.

## CHEMICAL ECOLOGY OF LEACH'S STORM PETRELS (*Oceanodroma leucorhoa*): MOLECULAR AND BEHAVIORAL APPROACHES

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Individual odors can be influenced by genes of the major histocompatibility complex (Mhc), which is a cluster of genes essential for immune function. These odors impact recognition and preference in mammals, lizards and fish, but whether MHC-associated odors could play a similar role in birds is currently not known. Procellariiforms form life-long pair bonds, and some species can tell each other apart using only odors. This presentation will emphasize recent investigations into the genetic and chemical basis for individual odor recognition in a common burrow-nesting species, the Leach's storm-petrel (*Oceanodroma leucorhoa*). We characterized partial genomic fragments from two MHC class IIB gene duplicates in this species. Locus-specific primers allowed us to assign 10 alleles (exon 2) to an Ocle-DAB1 MHC gene and 15 alleles to an Ocle-DAB2 MHC gene. Both loci displayed characteristics typical of functionally important MHC genes and up to 33 out of 90 codons of exon 2 comprising the peptide-binding region (PBR) showed decisive evidence for positive selection. The analysis of long genomic fragments also revealed a pattern of adaptive divergence of ancient gene duplicates that can be traced beyond the radiation of this avian order, and for birds has hitherto only been described among owls (Aves: Strigiformes). Contrary to the patterns in owls, we found species and locus-specific clustering of exon 2 sequences, suggesting adaptive divergence of the codons comprising the PBR as well. These loci



will provide the foundation for investigating odor-based mating preferences and self versus non-self recognition in this highly olfactory species.

## THE GLOBAL ISLANDS INVASIVE VERTEBRATE ERADICATION DATABASE: A TOOL TO IMPROVE AND FACILITATE RESTORATION OF ISLAND ECOSYSTEMS

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Islands are important for the conservation of biodiversity because they house 20% of terrestrial plant and vertebrate species, have suffered 64% of IUCN-listed extinctions and have 45% of IUCN-listed critically endangered species. There are 97 IUCN-listed threatened seabird species, all of which breed on islands, yet islands make up only about five percent of the earth's surface. The main cause of extinction and endangerment to seabirds on islands is the presence of invasive vertebrates. Fortunately, many future extinctions can be prevented by eradicating invasive vertebrates from islands. To assess the current state of this conservation tool, we are compiling a global database of terrestrial vertebrate eradications from islands, including successes and failures. To date, in the Global Islands Invasives Vertebrate Eradication Database we have documented approximately 1100 island eradication attempts involving 28 species of invasive vertebrates in 12 families. Most eradication attempts have been of rodents (>350) and bovid ungulates (>160). Moderate numbers of eradication attempts have been of cats (>90), suid ungulates (>55), and rabbits (>45). Most projects have been on islands smaller than 500 ha (68%) and in temperate climates (72%). Targeting eradications on larger and more tropical islands would lead to the protection of more seabird species. To this end, our vision is to maintain an accurate, web-accessible, regularly updated database that can be used to promote and improve the protection of island ecosystems by eradicating invasive vertebrates.

## HAWAIIAN ALBATROSSES SPATIAL DISTRIBUTIONS IN RELATION TO OCEANOGRAPHIC CONDITIONS DURING POST-BREEDING SEASON IN THE NORTH WEST PACIFIC

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Both Black-footed albatrosses (*Phoebastria nigripes*) and Laysan albatrosses (*P. immutabilis*) are distributed widely in the North Pacific. Recently, these marine top predators face serious threats such as fisheries by-catch and oil spills. Understanding the spatial distribution patterns of these highly migratory organisms and their habitat conditions, is crucial to designing effective management plans. Our objective was to study the species–oceanographic environment associations during post-breeding season in the Kuroshio–Oyashio transition zone in the North West Pacific. Sight-counting surveys were conducted in July and October 2010 on board the Shunyo-maru. Black-footed albatrosses were distributed over a wide range in this study area, but Laysan albatrosses density was higher in the eastern part in both July and October. To determine the environmental factor affecting their distribution, we developed a Generalized Linear Model (GLM) using sighting data and environmental data from satellite images with two spatial resolutions: 10 km and 50 km. We used four environmental predictors: sea surface temperature (SST), chlorophyll *a* concentration (Chl-*a*) and sea surface height anomaly (SSHA), Bathymetry (BAT). This model showed that the most important factor for Black-footed albatrosses and Laysan albatrosses distribution was sea surface temperature in both spatial resolutions. This study also highlighted that Laysan albatrosses preferred lower sea surface temperature than Black-footed albatrosses did.

#### SEARCH AND FISH: SEABIRDS AS AN ECOLOGICAL INDICATOR OF SCHOOLING TUNAS FOR JAPANESE POLE-AND-LINE FISHERIES IN THE WESTERN CENTRAL PACIFIC OCEAN.

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For seabirds, pelagic ocean is a severe habitat to search prey resources. In order to search prey efficiently, they use ecological and oceanographic indicators. Among those indicators, schooling of large marine predators is thought to be important. Tuna species are such large predatory fishes and are also commercially caught by fisheries. Japanese pole-and-line fishermen operating around the western central Pacific Ocean (WCPO) have traditionally used foraging flocks of seabirds as an important indicator of schooling tunas. To describe seabird community related to tunas and evaluate the effectiveness of the seabird indicator, we had an on-board research in a chartered pole-and-line vessel around tropical and temperate regions in the WCPO. We observed fishery operations and foraging flocks related to skipjack *Katsuwonus pelamis* and albacore *Thunnus alalunga* tuna schoolings, and then recorded seabird abundance and species composition, and catch data of the tunas. In the tropical region (3-12°S, 163-178°E, 265 operations), skipjacks were mainly caught, and terns, noddies, shearwaters, boobies and frigatebirds were related to them. Skipjack catch rate was statistically higher when more bridled terns *Sterna anaethetus* and brown noddies *Anous stolidus* aggregated. In the temperate region (30-42°N, 145-177°E, 457 operations), albacores were mainly caught and albatrosses and shearwaters were related.

Albacore catch rate was statistically higher when more Laysan albatrosses *Phoebastria immutabilis* or sooty shearwaters *Puffinus griseus* aggregated. Our result showed that many seabirds related to foraging tunas both in tropical and temperate region of the WCPO and they are also an effective indicator for the pole-and-line fisheries.

#### WINTER MIGRATIONS OF RED-LEGGED AND BLACK-LEGGED KITTIWAKES FROM THE PRIBILOF ISLANDS, ALASKA

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Understanding how seabirds utilize oceanic habitats during the non-breeding period is essential for helping to explain trends in population demography, breeding phenology, and pre-breeding body condition. Here, we compare the winter migratory habits of two sympatrically breeding congeners with different foraging strategies during the breeding season: black-legged kittiwakes (*Rissa tridactyla*) which are generalists and red-legged kittiwakes (*R. brevirostris*) which are specialists. Using geolocation loggers, 23 black-legged and 16 red-legged kittiwakes were tracked over the winter of 2010-11 from St George Island in the Bering Sea. The non-breeding distribution was distinctly different between species. The black-legged kittiwakes dispersed widely over the entire North Pacific Basin south of the Aleutian Islands but north of the North Pacific Transition Zone. In contrast, red-legged kittiwakes utilized two distinct regions 1) the western Bering Sea and 2) eastern Bering Sea. Overall, there was only 5% overlap in the 50% utilization distributions of each species during the non-breeding period, indicating that the core wintering habitats of each species are spatially and probably oceanographically distinct. Both species showed a high rate of breeding deferral and low hatching success in the subsequent breeding season signifying the potential for negative carry-over effects from the non-breeding period.

#### FORAGING SEGREGATION EXPRESSED BY HYDROGEN ISOTOPE VALUES: NEW INSIGHTS IN THE ECOLOGY OF MODERN AND ANCIENT SEABIRDS.

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The  $\delta D$  values of organisms are thought to reflect latitudinal trends in precipitation and have been used to study migratory birds, bats and butterflies. Marine organisms are not expected to show latitudinal variation because they rely on an isotopically homogeneous water source. However, for several colonies of Hawaiian Petrel (*Pterodroma sandwichensis*) and Newell's Shearwater (*Puffinus newelli*) there is a ~60 ‰ difference in the feathers of adults and chicks. Large differences are also exhibited for muscle and bone collagen. The variation in  $\delta D$  cannot be related solely to water source or evaporative loss. Instead, we propose that variation in  $\delta D$  values relates to variation in water loss imposed by differences in dietary salt loads; isoosmotic prey (squid) vs. hyposmotic prey (fish). This hypothesis is supported by data for seabirds from the transition zone. Individuals known to consume primarily squid versus fish exhibited a difference of 45 ‰ in  $\delta D$ . This suggests that  $\delta D$  can be used as a dietary indicator for modern and ancient seabirds. Our exploration of ancient isotopic records shows that variation in  $\delta D$  values has the potential to uncover previously intractable information on the foraging habits of seabirds.

## PLASTICS, PHTHALATES, AND PCB CONTAMINATION OF SEABIRDS FROM THE ALEUTIAN ISLANDS

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Rising levels of organic contaminants and heavy metals in marine ecosystems are of growing concern as they are being transported to the Arctic through atmospheric processes, oceanic currents and riverine input from industrialized regions. Contaminants have been detected in tissues from seabirds that inhabit the high Arctic, and a growing body of research has shown that seabirds from the Aleutian Islands have been exposed to organic contaminants and heavy metals. Research over two decades indicates that seabird populations are decreasing in the most western group of islands in the Aleutians (the Near Islands), while they are relatively stable in all of the other regions of the Aleutians. However, contaminant levels in tissues from seabirds breeding in the Near Islands have not been examined, and may possibly play a role in population declines. Because the ecosystems in the Near Islands are exposed to different environmental conditions from other islands in the Aleutian archipelago, seabirds in this region may also be exposed to different contaminant levels. We present results from analysis of tissues collected from 30 seabirds representing seven species that breed in the Near Islands for organic contaminant (PCBs), plastics, phthalates, and heavy metals and compare the results to contaminants data published from other regions in the North Pacific, Bering, and Arctic Ocean.

## LOCAVORE'S DILEMMA: FINE-SCALE FORAGING STRATEGIES OF CASPIAN TERNS

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Detailed movement behavior can help us understand how prey availability and foraging strategy influence daily activity and parental investment. We investigated the importance of local foraging conditions on the foraging behavior of Caspian terns (*Hydroprogne caspia*) by comparing fine scale movement behavior from individuals breeding at two colonies in the Upper Klamath Basin, California, with overlapping potential foraging areas. Data were collected from 12 breeding Caspian terns outfitted with remotely downloadable GPS transmitters, five breeding at the Sheepy Lake colony and seven from the Tule Lake colony, 30 km away. Caspian terns breeding at Sheepy Lake used a regional foraging strategy: they travelled further from the colony, (median 23 km, range: 3 - 53 km) and had longer foraging trips (median 240 min, range: 12 - 472 min). Terns breeding at Tule Lake used a local foraging strategy: they stayed close to the colony (median 6 km, range: 1 - 12 km) and made shorter foraging trips (median 52 min, range: 12 - 292 min). Caspian terns foraging at a regional scale (>20 km from the colony) spent more time commuting, more time loafing away from the colony, and less time attending the nest. Even for colonies with significant overlap in potential foraging areas, local conditions can result in markedly different foraging strategies. For single-prey loading species that need to provision chicks frequently, like Caspian terns, foraging conditions immediately surrounding the breeding colony might be more important to productivity than conditions within the entire foraging range.

## A NON-DESTRUCTIVE OPTION FOR MANAGING A LARGE DOUBLE-CRESTED CORMORANT COLONY: PRECISE REDUCTION OF NESTING HABITAT

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The largest known breeding colony of Double-crested Cormorants (*Phalacrocorax auritus*) is located on East Sand Island, in the Columbia River Estuary. In 2010 this colony was home to approximately 13,600 breeding pairs, about 40% of the West Coast population. This concentration of piscivorous seabirds has raised concerns among fisheries managers due to annual consumption of millions of out-migrating juvenile salmonids (*Oncorhynchus* spp.) listed under the Endangered Species Act. We investigated a non-lethal management option for precisely reducing available nesting habitat for cormorants at the East Sand Island colony. A 2.6-m high by 50-m long chain link privacy fence was constructed prior to the breeding season to visually isolate 15% of the previous year's nesting area. Researchers were stationed in a camp on the dissuasion side of the fence for the first several weeks of the breeding season. After 13 days, with between one and nine researcher incursions per day, cormorants ceased initiating nests within the dissuasion area. Sixty cormorants were captured in the dissuasion area and radio-tagged prior to the initiation of dissuasion efforts. Ninety-seven percent of tagged cormorants were subsequently detected on the main colony during the breeding season. Preliminary data also suggest limited impact on cormorants nesting adjacent to the fence or on other non-target species, including nesting gulls and roosting California Brown Pelicans

(*Pelecanus occidentalis californicus*). A visual barrier fence, in conjunction with human disturbance, represents a viable management option for reducing available nesting habitat for Double-crested Cormorants, while limiting impacts to adjacent breeding and roosting birds.

## THE BUREAU OF OCEAN ENERGY MANAGEMENT AND OFFSHORE RENEWABLE ENERGY DEVELOPMENT: ASSESSING AND STUDYING EFFECTS TO SEABIRDS

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The mission of the Bureau of Ocean Energy Management (BOEM) is to manage development of the nation's offshore energy and mineral resources in an environmentally and economically responsible way. The Department of the Interior has delegated discretionary authority to BOEM to issue leases, easements or rights-of-way for renewable energy activities, including wind, wave, ocean current, solar and hydrogen, on the Outer Continental Shelf (OCS). These activities require an assessment of the potential environmental impacts to resources on the OCS and evaluation of related technical issues. The BOEM has two programs to conduct studies and research related to renewable energy: the Environmental Studies Program (ESP) and the Technology Assessment and Research Program (TA&R). Through ESP, BOEM collects a wide range of environmental information to provide an improved understanding of offshore ecosystems, a baseline for assessing cumulative effects, and the scientific basis for development of regulatory measures to mitigate adverse impacts. The BOEM, formerly Minerals Management Service, has funded a variety of seabird studies to assess the effects of oil and gas production. The focus of BOEM's environmental studies program in the Pacific OCS Region now includes evaluating the effects of renewable energy development on the OCS. Studies underway or proposed include aerial surveys of seabirds and marine mammals off the Pacific northwest, assessing vulnerability of birds to offshore renewable energy devices, artificial lighting effects on Xantus's Murrelets (*Synthliboramphus hypoleucus*) and Ashy Storm-Petrels (*Oceanodroma homochroa*), inventory of nearshore bird species, and predictive modeling of seabird occurrence in the Pacific.

## SEABIRD AND FORAGE FISH DISTRIBUTION PATTERNS IN A PROPOSED OCEAN ENERGY DEVELOPMENT REGION

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Recent renewable energy zoning proposals for the Oregon Territorial Sea include potential wave, wind, and tidal energy sites near the mouth of the Columbia River, USA. Ecosystem surveys between Newport, OR and Cape Flattery, WA indicate that this region is a "hot spot" for seabirds including sooty shearwaters (*Puffinus griseus*) and common murre (*Uria aalge*). Birds and forage fish species including northern anchovy (*Engraulis mordax*), sardine (*Sardinops sagax*), and smelt (*Osmeridae*) are attracted to oceanographic fronts created by recently discharged river water. Introduction of ocean energy devices may affect bird and fish distributions by creating physical structure in ocean habitat where no structure previously existed. Information about spatial relationships between birds and fish in unaltered shelf habitat are lacking in this region. We began collecting fisheries acoustics data using a split-beam, four

frequency Simrad EK60 system during ongoing seabird surveys along the Oregon and Washington shelf waters in 2011. We present preliminary data on seabird and forage fish species composition, abundance, and distribution from strip transect surveys, acoustics, and net samples. This data can be used to inform marine spatial planning, including renewable energy site selection and infrastructure design involving cables, buoys, and other fixed structures. Utilizing data on multiple trophic linkages will ensure minimal impacts to seabird and prey populations during installment and use. Long term, cohesive datasets will also provide a means to evaluate before and after effects on these populations and determine cumulative impacts across renewable energy device arrays and at multiple sites.

## ISLAND IN THE STREAM: UPWELLING AND MARINE HOTSPOTS AROUND THE KODIAK ARCHIPELAGO

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More seabirds breed and forage downstream of the Kodiak archipelago than along the entire coast of the northeast Gulf of Alaska (GOA). Why? Coastal waters are mostly downwelled in the northeastern GOA, effectively capping much of the continental shelf in this region with a warm surface layer of water that lacks a renewable source of nutrients to sustain primary production. In contrast, as currents flow southwestward on the shelf and strike the Kodiak archipelago, upwelling of cold, nutrient-rich waters stimulates primary production and creates a productive hotspot in the northern GOA. This local production is carried downstream, enhancing biological productivity on the Alaska Peninsula shelf and supporting the largest and most diverse seabird colony in the GOA (Semidi Islands). Currents, bottom topography, temperature, and turbulence all play a role in structuring marine communities upstream and downstream of the Kodiak archipelago. We examine some patterns of plankton, fish, bird, and mammal communities in the region, and consider some of the broader implications of the current regime that fuels this extraordinary shelf ecosystem.

## SEX-SPECIFIC FORAGING STRATEGIES THROUGHOUT THE BREEDING SEASON IN A TROPICAL, SEXUALLY-MONOMORPHIC SMALL ENDEMIC PETREL (INDIAN OCEAN)

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Two hypotheses are proposed to explain sex-related differences in foraging in sexually monomorphic seabirds. The ‘inter-sexual competition’ hypothesis suggests that parents are in competition and that the dominated sex must adapt its behaviour to avoid competing with the dominant sex. The ‘energetic constraint’ hypothesis suggests that differential energetic requirements lead to different foraging behaviour. The goal of our study was to examine sexual differences in



foraging behaviour of a sexually-monomorphic tropical seabird, the Barau's petrel (*Pterodroma barau*). We found clear sexual differences in foraging habitats and activities, but these differences were not consistent throughout the breeding period. During the pre-laying exodus, males foraged further to the colony, in a richer area, and they were more active than females. Males systematically took the first long incubation shift that was always longer than the others. However, no sex-related differences in foraging behaviour were observed during the chick-rearing period, both sexes sharing the rest of the parental duty equally. We suggest that the sexual differences observed during the first part of the breeding period are due to the specific needs of males and females. Females need to restore their body condition as quickly as possible after laying, which forces males to take the first long incubation shift at the nest. This may explain why males forage more actively during the pre-laying exodus, to prepare themselves for this long fasting period. Our results support for the first time the "energy constraint" hypothesis to explain sexual differences in behaviour of a small sized monomorphic seabird.

#### A MULTI-SCALE APPROACH TO UNDERSTAND THE BREEDING HABITAT SELECTION OF BARAU'S PETREL ON REUNION ISLAND (INDIAN OCEAN)

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The Barau's petrel (*Pterodroma barau*) is an endemic and endangered seabird of Réunion Island. We examined the habitat selection of this species when breeding in order to identify its ecological needs during this crucial phase of its life cycle and to investigate the interactions between nesting habitat and breeding success. Nesting habitats were studied at three spatial scales: the upper part of Réunion Island, breeding colonies and nesting burrow. The available habitat, selected habitat and breeding success were compared between the two colonies ('Piton des Neiges' and 'Grand Bénare'). Our results show that Barau's petrel breeds between 2,400 and 2,700 m above sea level, on cliff and ridge with a steeper slopes. At the scale of the colony, stable substrate enables the development of a perennial plant cover, which itself led to the formation of deep humus where birds can dig their burrows. At the opposite, unstable substrate (rock slide) leads to a regeneration of vegetation and a modification of the substrate limiting the humus accumulation. These differences lead to differences in burrow density and breeding success. Using habitat selection criteria, we also developed a predictive model of habitat selection to map all potential habitats for this species. This map will be a powerful tool to design adaptive conservation actions in the future in the core area of the National Park of Réunion Island.

#### RECENT CHANGES AT THE TOP AND BOTTOM OF THE CENTRAL NORTH PACIFIC SUBTROPICAL ECOSYSTEM

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Over the past decade changes in both the top and bottom of the central North Pacific subtropical ecosystem have been observed.

At the bottom of the ecosystem, a 9-year time series of SeaWiFS remotely-sensed ocean color data found that the North Pacific's most oligotrophic waters, those with surface chlorophyll not exceeding 0.07 mg chl/m<sup>3</sup> have expanded in area by about 3% per year, concurrent with increased sea surface

temperatures. Median cell size estimated from satellite remotely-sensed chlorophyll and temperature declined by about 2% in the subtropical North Pacific over the period 1998-2007.

At the top of the subtropical ecosystem in the subtropical North Pacific, standardized catch rates for the 13 most abundant species caught in the deep-set Hawaii-based longline fishery over the past decade (1996–2006) provide evidence of a change among the top predators. Catch rates for apex predators such as blue shark (*Prionace glauca*), bigeye (*Thunnus obesus*) and albacore (*Thunnus alalunga*) tunas, shortbill spearfish (*Tetrapturus angustirostris*), and striped marlin (*Tetrapturus audax*) declined by 3% to 9% per year while catch rates for four mid-trophic species, mahimahi (*Coryphaena hippurus*), sickle pomfret (*Taractichthys steindachneri*), escolar (*Lepidocybium flavobrunneum*), and snake mackerel (*Gempylus serpens*), increased by 6% to 18% per year. The mean trophic level of the catch for these 13 species declined 5%, from 3.85 to 3.66. A shift in the ecosystem to an increase in mid-trophic-level, fast-growing and short-lived species is indicated by the decline in apex predators in the catch (from 70% to 40%) and the increase in species with production to biomass values of 1.0 or larger in the catch (from 20% to 40%). This altered ecosystem may exhibit more temporal variation in response to climate variation.

#### WHAT THE NOSE KNOWS BEST: VOLATILES FROM FEATHERS AND NEST SOIL AS POTENTIAL INDIVIDUAL ODOR SIGNATURES IN TWO DISTINCT PETREL SPECIES

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Previous forensic work has shown that humans can be differentiated by their scent using chemical ratios that determine their individual odor profile. Using this forensic approach, we are studying two seabird models, Gould's petrel (*Pterodroma leucoptera*) and Leach's storm petrel (*Oceanodroma leucorhoa*), to determine whether we can analytically differentiate individuals by sex, population or species based solely on chemical profiles of feather and burrow samples. The instrumental technique used for this analysis is Solid Phase Microextraction coupled with Gas chromatography/Mass spectrometry (SPME-GC/MS). Contrary to commonly used solvent extractions, SPME offers a rapid and reliable method for the study of scent, i.e. volatiles emanating from the collected samples. Compared to prior studies that used solvent extractions, we have identified (and used external calibration to confirm) a much wider range of functional groups, including aliphatic hydrocarbons, aldehydes, ketones and aromatic terpenes. We have used forensic analytical methods developed for law enforcement purposes to identify compounds occurring at high frequency, and have now successfully used these subsets to differentiate individual odor signatures. We are currently applying these methods to test whether we can find sex and geographic origin markers from feather and burrow samples.

#### FIRST DEMONSTRATION THAT PROCELLARIIFORMS CAN SMELL PLASTIC: THE GOOD, THE BAD, AND THE IMPLICATIONS

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Increase in plastic production since the 1960s and consequent plastic pollution in marine habitat correlates with a dramatic rise in the consumption of plastics by seabirds. The potential for chemical attraction to these plastic odorants has never been studied. The compound 2-ethyl-1-hexanol is a known contaminant emitted from common plastics. It is also a key volatile compound used in canine training for the detection of cast/polymer containing explosives. We are adapting similar odor delivery methods currently employed for canine explosive detection to test whether petrels can detect plastics. In this study, the primary model being used is Leach's storm petrel (*Oceanodroma leucorhoa*). Controlled odor mimic permeation systems (COMPS) were chosen as an optimized method of delivering known concentrations of this plastic odor signature. COMPS devices have never been used on birds and our lab is the first one to implement this technique in an avian model. Using an established behavioral assay, we tested birds' responses to high (of 230 ng/sec), and low (156 ng/sec) dissipation rates. At the high dissipation rate, birds could discriminate and were averted to the test compound (n=18;  $p < 0.001$ , binomial test). However, aversion was reduced by lowering the dissipation rate by half (n= 50;  $p < 0.05$ , binomial test). These results establish that a procellariiform species can smell at least one previously identified plastic odor compound, and that attraction varies with concentration. Since scent attraction can vary with potency, our results suggest that detection thresholds need to be better quantified.

#### UPDATED INFORMATION ON BRYAN'S SHEAWATERS (*PUFFINUS BRYANI*) IN THE NORTH PACIFIC OCEAN, WITH A LOOK TOWARD ITS CONSERVATION

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A new species of Procellariiform, Bryan's Shearwater (*Puffinus bryani*), was described by Pyle, A. J. Welch, and R. C. Fleischer in 2011 based on a specimen collected by Amerson in February 1963 on Midway Atoll, Northwestern Hawaiian Islands. It had been misidentified as a Little Shearwater (*P. assimilis*) but genetically appears closer to a clade including the Newell's Shearwater (*P. newellii*) of the Southeastern Hawaiian Islands. During the winters of 1990-1991 and 1991-1992, a second Bryan's Shearwater was discovered calling in a rock crevice near the northeast corner of Sand Island, Midway, and photographed, videotaped, and audiotaped by David and Eilerts in December 1991. These two records likely represented prospecting individuals, and the locations of source colonies of Bryan's Shearwaters remain unknown. There have also been several reports of Little Shearwaters in the North Pacific that may or may not have represented mis-identified Bryan's Shearwaters. Here we present updated information on seasonality, breeding habitat requirements, and vocalizations of Bryan's Shearwaters based on the 1963 and 1991 records, and we review potential at-sea records in the North Pacific. Bryan's Shearwaters are undoubtedly rare and, if extant, may need targeted conservation actions to increase their population size. We present ideas on the potential breeding and foraging ranges, breeding habitat, and next conservation steps to protect this newly discovered seabird.

## ENSURING A FUTURE FOR THE NEWELL'S SHEARWATER

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The Newell's Shearwater (*Puffinus newelli*) has suffered from an estimated population decline of 75% in the past two decades, with known terrestrial threats including predation by invasive vertebrates, loss of breeding habitat, light attraction and collision with artificial structures. Recovery actions already undertaken include the recent initiation of predator control projects at colonies in Upper Limahuli and Hono o Na Pali, reduction in light pollution, rescue of 'fall-out' fledglings attracted by artificial light sources and the mapping and prioritization of the remaining distribution of colonies within Kauai's interior. Despite these combined efforts, the majority of known breeding populations remain largely unprotected, unmonitored and unmanaged. Recently legal proceedings have yielded positive outcomes to expand recovery actions, with funding mechanisms including Habitat Conservation Plans (HCP) by entities previously engaging in illegal take. The planned Kauai Seabird HCP holds significant potential to fund seabird recovery on Kauai for the next 30 years. Necessary remaining recovery tasks include increasing the scale and effectiveness of predator control projects, considering the use of predator-proof fences to secure key colonies, concentrating effort on the Northwest shore of Kauai where light and powerline threats are at a minimum, and the translocation of individuals to locations entirely free of predators, lights and powerlines. Ensuring the future for Newell's Shearwater requires existing conservation actions to be effectively scaled up, the continued development of Hawaii-based skillsets (particularly those involving translocation and predator eradication) and securing long-term funding mechanisms.

## STATUS AND TREND OF NESTING HABITAT FOR THE MARBLED MURRELET IN THE PACIFIC NORTHWEST

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The primary objectives of the effectiveness monitoring plan for Marbled Murrelets (*Brachyramphus marmoratus*) include mapping baseline nesting habitat (at the start of the Northwest Forest Plan [the Plan]) and estimating changes in that habitat over time. Using vegetation data derived from satellite imagery, we modeled habitat suitability using a maximum entropy model. We used Maxent software to compute habitat suitability scores from vegetation and physiographic attributes based on comparisons of

conditions at 342 occupied sites and average conditions over all forested lands in which murrelets occurred. We estimated 3.8 million acres of higher suitability nesting habitat over all lands in the murrelet's range in Washington, Oregon, and California at the start of the plan (1994/96). Most (89%) baseline habitat on federal lands occurred within reserved-land allocations. A substantial amount (36%) of baseline habitat occurred on nonfederal lands. Over all lands, we observed a net loss of about 7% of higher suitability potential nesting habitat from the baseline period to 2006/07. If we focus on losses and ignore gains, we estimated a loss of 13% of higher suitability habitat present at baseline, over this same period. Fire has been the major cause of loss of nesting habitat on federal lands since the Plan was implemented; timber harvest was the primary cause of loss on nonfederal lands. We also found that murrelet population size was strongly and positively correlated with amount of nesting habitat, suggesting that conservation of remaining nesting habitat and restoration of currently unsuitable habitat is key to murrelet recovery.

## RED-FOOTED BOOBY COLONY SIZE FLUCTUATIONS REFLECT THEIR PELAGIC FORAGING HABITAT

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Red-footed booby populations in Hawai'i have increased and expanded range during the last 65 years for which we have data. Three new sites; Mokapu Peninsula on O'ahu and Kilauea Point on Kaua'i and one in the Northwestern Hawaiian Islands Tern Island were colonized have become the largest breeding colonies in the archipelago. The growth of these colonies is coincident with reduced human disturbance at each site and expansion of tuna fisheries, changes in the Pacific Decadal Oscillation (PDO), and global warming. Numbers of breeding boobies in the colony may reflect the opposing effects of reduced abundance of pelagic fish predators that compete with boobies for epipelagic prey but also reduced capacity for providing sub-surface predator-facilitated foraging interactions critical to boobies. This apparent paradox may have to do with differential depletion of subsurface predator species with large tuna and billfish reduced in number but smaller surface schooling tuna remaining abundant. Red-footed booby population increases in the 1970's occurred during a period of high oceanic productivity associated with the Aleutian Low Pressure System, a component of the Pacific Decadal Oscillation (PDO) which increases ocean mixing. After oceanic productivity declined in the late 1980s, booby reproductive success declined in the Northwestern Hawaiian Islands. Population sizes since 1990 have increased 60%, peaking by the end of the decade. Since the early 2000's population sizes at each colony measured have been congruent with the PDO cycle.

## PATTERNS OF CHANGE IN DIETS OF TWO PISCIVOROUS SEABIRD SPECIES DURING 35 YEARS IN THE PRIBILOF ISLANDS

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As upper level predators, seabirds reflect fluctuations in the marine environment that influence their prey supply. Studies of seabird diets thus provide insight into the physical and biological mechanisms that potentially drive population changes in both predators and their prey. The eastern Bering Sea shelf, among the most productive marine ecosystems in the world, has undergone significant restructuring in recent decades that is likely to continue with anticipated climatic change. We examined temporal patterns in diet and relationships with oceanographic variables over 35 years (1975-2010) at two Pribilof Islands for piscivorous black-legged kittiwakes and thick-billed murre. Diets varied significantly among years and between islands and species. Our dataset affirmed the importance of pollock in kittiwake diets; capelin were absent in diets of either species since the late 1970's. Diets of both species contained more gadids at St. Paul and more squid and euphausiids at St. George, likely reflecting differences in foraging location between islands. We found relationships between kittiwake diet and broad-scale oceanographic variables but not with local physical variables. Almost no time-series data exist on availability and abundance of zooplankton or forage fish such as age-0 pollock, myctophids or sandlance in the Bering Sea. Our measure of diet appears too coarse for detecting complex relationships between local oceanographic variables and seabird responses, but may provide invaluable information about changes in forage fish stocks, which are frequently expensive or difficult to otherwise measure. Future diet analyses should increase emphasis on evaluating caloric input and murre chick diet composition.

#### COMPARING THE PERFORMANCE OF PREDICTIVE MODELS TO ESTIMATE THE ABUNDANCE AND DISTRIBUTION OF SEABIRDS AT SEA

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Predictive modeling of the spatial distribution of marine organisms is needed in a large number of management applications including assessing the impact of industrial development, like windfarms or oil and gas extraction, planing marine reserves, and identifying critical habitat for endangered species. Much recent effort has focused on present/absence data, including evaluations of available methods. Here we address the spatial distribution of density (animals/area), which allows answering of more relevant questions and presence/absence distribution alone. Methods can be classified into those using spatial information to interpolate between existing measurements and those using purely environmental habitat variables for prediction. Since many methods include some form of model selection, we use 10-fold cross-validation to assess the performance of predictive models. We use five Alaskan seabird species, covering pelagic as well as coastal species and the following modeling approaches: GLMMs, GAMs, MARS, random forest, ordinary kriging, and universal kriging. Differences between methods were generally small, but overall random forests showed the best performance. Kriging performed poorly for the pelagic species, but was superior coastal species. Considerations other than predictive power may be more important than selection of modeling algorithms.

## SEABIRD PROTECTION NETWORK: REDUCING HUMAN DISTURBANCES THROUGH MONITORING, COORDINATED MANAGEMENT, ENFORCEMENT, OUTREACH AND EDUCATION

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As the amount of people interacting with the marine environment increases, so does the potential for inadvertent negative human-seabird interactions that disrupt seabird nest prospecting, resting, breeding, feeding, and mating rituals, causing egg or chick loss, or complete colony abandonment in extreme cases. The Seabird Protection Network (Network) works in collaboration with federal and state agencies, non-governmental organizations and stakeholders to improve the survival and recruitment of seabird colonies by reducing human disturbance at breeding and roosting sites, where humans have the most detrimental impact on recruitment. This poster focuses on the success of the Network, which has been demonstrated through a comprehensive plan targeting the main sources of human disturbance –boaters, pilots and humans on foot –by implementing: 1) a multi-agency management and enforcement program that helped site and implement special marine protected areas, known as no-access Special Closures; 2) an organized outreach program that includes targeted stakeholders and can help ocean users and pilots understand how to protect seabird colonies; and 3) a monitoring and adaptive management program, to effectively address the sources of seabird disturbance, linked with population trends. The framework of Bodega Head to Pt. Sur Chapter of the Network that includes the largest concentration of breeding seabirds in the contiguous United States, will be used to show how these efforts can be applied throughout the Pacific Region.

## TROPHIC ECOLOGY OF MARINE BIRDS OF THE FAR WESTERN ALEUTIAN ISLANDS USING STABLE ISOTOPES

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Research over two decades indicates that seabird populations are decreasing in the most western group of islands in the Aleutians (the Near Islands), while they are relatively stable in all of the other regions of the Aleutians. Gyral currents, like the one found in this region, tend to create a distinct oceanographic ecosystem with its own marine fauna, upper-water food web, and ecological dynamics. These tidal/current gyral systems could be a major force driving the ecological structuring of the Near Islands fish and plankton populations. Climate change has dramatically affected the direction, strength, and biological oceanography of Aleutian currents over time, and there is a growing body of evidence that indicates these changes are continuing to strengthen. If there is a direct connection between the climate change forcing, food prey, and seabird foraging; then diet analysis should provide evidence that Near Island seabirds are ecologically decoupled from the other Aleutian populations. Results from  $\delta^{15}\text{N}$  and  $\delta^{13}\text{C}$  stable isotope analysis of feathers, muscle, liver, kidney and heart represent pioneering research for



this region that allows a multidimensional and temporally discrete look at the proxies determining the dynamics of trophic ecology of seabird diets. Deep longitudinal analysis of seabirds collected over a decade from the same location allow quantification of diet and food web dynamics through timescales sufficiently long to present putative effects by climate change.

## EFFECTS OF AIR AND WATER TEMPERATURE ON RESTING METABOLISM OF AUKLETS AND OTHER DIVING BIRDS

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For small aquatic endotherms, heat loss while floating on water can be a dominant energy cost, and requires accurate estimation in energetics models for different species. We measured resting metabolic rate (RMR) in air and on water for a small diving bird, the Cassin's auklet (*Ptychoramphus aleuticus*), and compared these results to published data for other diving birds of diverse taxa and sizes. For 8 Cassin's auklets (~165 g), the lower critical temperature was higher on water (21°C) than in air (16°C). Lowest values of RMR (W kg<sup>-1</sup>) averaged 19% higher on water (12.14 ± 3.14 SD) than in air (10.22 ± 7 1.43). At lower temperatures, RMR averaged 25% higher on water than in air, increasing with similar slope. RMR was higher on water than in air for alcids, cormorants, and small penguins, but not for diving ducks which appear exceptionally resistant to heat loss in water. Changes in RMR (W) with body mass either in air or on water were mostly linear over the 5- to 20-fold body mass ranges of alcids, diving ducks, and penguins, while cormorants showed no relationship of RMR with mass. The often large energetic effects of time spent floating on water can differ substantially among major taxa of diving birds, so that relevant estimates are critical to understanding their patterns of daily energy use.

## MIGRATORY MOVEMENTS AND WINTERING SITES OF RED-THROATED AND YELLOW-BILLED LOONS FROM THE ARCTIC COASTAL PLAIN, ALASKA

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Red-throated (*Gavia stellata*) and Yellow-billed (*G. adamsii*) loons are waterbird species of conservation concern due to population decline and small population size, respectively. These species nest on tundra habitats in Alaska and reside on coastal marine waters when not occupying lakes. Despite their reliance on the marine environment, little is known regarding loon use of coastal habitat, migration routes, or wintering sites. To describe loon distribution on the marine environment, we deployed satellite transmitters on Red-throated (n=26) and Yellow-billed (n=34) loons captured on the Arctic Coastal Plain of Alaska from 2000 to 2010. Locations from transmitters indicated that loons departed inland lakes from

late-August through September. Most (93%) loons migrated through the Chukchi Sea to wintering areas primarily located in Asia, from the Japanese Archipelago to the Korean Peninsula. During spring migration, loons were first detected offshore from the Arctic coast of Alaska in June and moved inland to lakes shortly after arrival. Red-throated Loons used marine habitat for foraging throughout the summer. During migration, loons were located nearshore at average distances of 6.61 km (range 0.06-56.69 km) and 20.3 km (range 0.04-144.0 km) from the coast for Red-throated and Yellow-billed loons respectively. These preliminary results indicate that nesting adult loons reside nearshore on the Chukchi and Beaufort sea coasts primarily during the months of June, August, and September; however, some Yellow-billed Loons were located on coastal waters throughout summer. Locations of PTT-tagged loons indicate strong connectivity between nesting grounds on the Arctic Coastal Plain and wintering sites in Asia.

## SEABIRDS AND THE ADAPTIVE MANAGEMENT OF MARINE PROTECTED AREAS IN CENTRAL CALIFORNIA

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The Applied California Current Ecosystem Studies (ACCESS) is a partnership between government agencies, academia, scientists, and NGOs to support marine wildlife conservation and healthy marine ecosystems in northern and central California. ACCESS uses ocean research to inform resource managers, policy makers and conservation partners. Here we use ACCESS as an example of how multidisciplinary partnerships can shape ecosystem-based adaptive management. New initiatives for establishing marine protected areas (MPAs) consistently mandate adaptive management approaches without clearly defining what adaptive management means. Adaptive management of MPAs should begin with hypothesis driven questions that help define realistic expectations of MPA success. The questions should address 1) what community-level changes are expected to occur as a result of MPA establishment and 2) how quickly these changes should take place. Recovery rates of populations released from fishing pressure will be highly dependent on the local and regional biophysical processes that determine juvenile recruitment rates. Here we use studies of seabird diet and foraging distribution to illustrate how temporal variability in primary and secondary productivity on the regional scale can translate into spatial variability in fish recruitment on the local scale. Spatial variability in fish recruitment has direct implications for the placement of MPAs. For example, MPAs established in larval retention areas will likely respond faster than MPAs receiving little recruitment. As most nearshore communities are open systems affected by biophysical processes, anticipating changes within a given MPA will require accounting for factors acting outside the MPA as well as inside.

## SEABIRD DIET AS AN INDICATOR OF ANNUAL VARIABILITY IN JUVENILE ANCHOVY AND ROCKFISH RECRUITMENT

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Northern anchovies (*Engraulis mordax*) and juvenile rockfish (*Sebastes sp.*) are staples in the diets of many marine predators and should be managed with an ecosystem-based approach that benefits both human and marine predator consumption. Such an approach should assess stocks from both the fishery's and predator's perspective. We investigated the California Least Tern (*Sternula antillarum browni*) as a potential indicator of juvenile recruitment in anchovy and rockfish populations. We studied diet at a breeding colony in central California for eleven years (2001-2011) and discovered a strong positive relationship between dietary anchovy and rockfish occurrence and annual tern reproductive success. Additionally, we compared annual diet to measures of regional anchovy and rockfish larval abundance at various temporal scales. We found positive correlations when larval abundances were measured during the spawning season prior to the tern breeding season. Finally, we compared tern diet to indices of regional oceanic productivity and found strong correlations when indices were averaged from the end of the spawning seasons through the tern breeding season. Anchovy occurrence was correlated with El Nino and Pacific Decadal Oscillation indices averaged from winter through summer, while rockfish occurrence was correlated with sea surface temperature averaged from spring through summer. Thus, Least Tern diet is responding to variability in both larval production and factors leading to larval survival. These results provide insight into oceanographic variables important to the survival of anchovy and rockfish larvae and suggest a potential for using seabird diet to detect variability in juvenile recruitment to adult populations.

#### EFFECTS OF TARSUS-MOUNTED GEOLOCATORS ON REPRODUCTIVE FITNESS OF ADULT CRESTED AUKLETS (*AETHIA CRISTATELLA*)

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Recent advances in smaller, lighter geolocators have encouraged the widespread use of such devices on a variety of species to track their movement across large distances. For species of seabirds, the mass of geolocators is traditionally recommended to be less than 3% of total body mass to insure that resultant migration data reflects natural movement of a species. Growing evidence indicate that effects of geolocators vary dramatically across species and have shown significant impacts on reproductive fitness even within this recommendation. To evaluate effects of geolocators on adult fitness of a small pelagic seabird, we deployed tarsus-mounted geolocators (Lotek LAT2900) on adult Crested Auklets (*Aethia cristatella*) from a breeding site on Buldir Island, Alaska. Preliminary results of our study show that the geolocators had no significant effect on an adults' ability to provision young, as seen by chick growth, and no significant effect on nest productivity. Future work aims to quantify potential effects of geolocators on adult body condition, and subsequent reproductive success.

#### ON THE NEED FOR PROLIFERATION OF INTERNATIONAL AGREEMENTS FOR SEABIRD PROTECTION IN THE PACIFIC OCEAN BASIN

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The global migrations and high seas habitats of seabirds necessarily make their conservation an international endeavor. Regulations governing the marine province are shifting from the (*Mare Libre*) (free ocean) concept to one of increasing mutual regulation based on the precautionary principle and ecosystem-based management strategies. Concurrently, agreements pertaining to anthropogenic perturbations to seabirds on the high seas have also proliferated. The Convention on the Conservation of Antarctic Marine Living Resources (CCAMLR), the Agreement on the Conservation of Albatrosses and Petrels (ACAP), and the African-Eurasian Migratory Waterbird Agreement (AEWA) are especially successful and have resulted in tangible protection of seabirds in part due to their specificity. CCAMLR and ACAP have lowered bycatch while AEWA has protected more than 1000 Important Bird Areas (IBAs). Also, the Convention on the Conservation of Migratory Species (CMS) has played an important role in the proliferation of seabird-specific treaties. A notable gap in protection for Pacific Basin seabirds is a lack of legislation designed to protect flyways and migratory pathways. AEWA has accomplished this in Africa and Eurasia and could be used as a model to develop similar legislation in the Pacific. We contend that an important goal for any new agreement is the inclusion of a holistic strategy. Conserving seabirds necessitates nesting and feeding site protection, fisheries regulation, and marine pollution mitigation among other measures. Integration of all strategies under a single legislative framework allows for the efficient allocation of resources to the approaches that provide the most cost-effective protection.

#### RESTORATION OF PIGEON GUILLEMOTS AND OTHER SEABIRDS ON CHERNABURA AND SIMEONOF ISLANDS, ALASKA SINCE FOX REMOVAL IN 1995

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The introduction of arctic fox (*Alopex lagopus*) to many islands along the Alaska Peninsula in the late 1800s to early 1900s reduced nesting populations of seabirds. In 1994 and 1995, the Alaska Maritime National Wildlife Refuge eradicated fox from Chernabura and Simeonof islands in an effort to restore several species, including pigeon guillemot (*Cephus columba*). At the time of removal, nearshore boat survey results estimated 1 pigeon guillemot per km of coastline despite the presence of suitable nesting habitat. Predictions made at that time suggested both of these islands would eventually have hundreds of nesting guillemots. Surveys have been repeated at these two islands in 2001, 2006, and/or 2011, as well as neighboring islands in the Shumagin Island group without history of fox presence (Atkins, Bird, Herendeen, and Murie Islets). Between 1995 and 2011, Pigeon guillemot numbers have increased six-fold on Chernabura (from 28 to 187 birds) and four-fold on Simeonof (from 4 to 17 birds). On neighboring islands, numbers have remained stable or slightly declined. Sixteen years post fox removal, restoration efforts are benefitting pigeon guillemots, although not yet to the numbers predicted if all potential nesting habitat was occupied. Other species have increased in numbers and established or increased nesting colonies, particularly ground-nesters that could not nest successfully with fox present. Glaucous-winged gull (*Larus glaucescens*), the most common species, increased three-fold on both islands. Mew gull (*Larus canus*) increased 18-fold and arctic tern (*Sterna paradisaea*) four-fold on Simeonof.

## HOTSPOTS OF SEABIRD ABUNDANCE AND DIVERSITY IN THE NORTHWEST ATLANTIC

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We used a long term database (1975-present) to identify those parts of the U.S. continental shelf waters between Maine and North Carolina that have persistently elevated abundance and diversity of seabirds. We construct specific definitions of "elevated" and "persistent" and apply these to this 40 record of seabird distribution. We identified hotspots of abundance off Massachusetts, off the mouth of Chesapeake Bay and on Georges Bank. these abundance hotspots coincided with hotspots of diversity, and we also identified a hotspot of diversity within the Gulf Stream. Identification of these hotspots should be helpful in informing marine policy and decisions about development on the continental shelf.

## IDENTIFICATION OF MARINE IMPORTANT BIRD AREAS IN JAPAN

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The Marine Important Bird Areas (Marine IBAs) Programme of BirdLife International uses standardised, globally agreed criteria to identify marine areas that are critical to the conservation of seabirds and marine biodiversity. These sites will make a vital contribution to achieving protection and sustainable management of the oceans, particularly by linking to the future designation of Marine Protected Areas (MPAs). Following the target set by the 10th Conference of the Parties to the Convention on Biological Diversity (CBD COP10), the Japanese government intends to designate 10% of its waters as MPAs by 2020; it is also considering identifying important marine biodiversity areas which cannot be designated as MPAs under the current laws. To input to this process, Wild Bird Society of Japan is identifying a suite of marine IBAs in Japan using analysis of seabird foraging range data, for four species of seabirds: Roseate Tern (*Sterna dougallii*), Black-naped Tern (*Sterna sumatrana*), Japanese Murrelet (*Synthliboramphus wumizusume*) and Rhinoceros Auklet (*Cerorhinca monocerata*). To supplement this information a study on potential factors that may influence the at-sea distribution of murrelets in the breeding season is being undertaken. We present the preliminary results of the identification of marine IBAs, discuss conceptual and practical challenges associated with the identification process in order to show how we might input to the Japanese MPA designation process and the implications this may have for seabird conservation.

## PHYSICAL FORCING ALTERS BOTTOM-UP CONTROL IN CENTRAL CALIFORNIA: A TALE OF TWO SEABIRDS

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The pelagic ecosystem of the Central California Current is typically thought to be driven by bottom-up forcing. Annual productivity is primarily determined by the amount of nutrients brought to the surface through wind-driven upwelling. Under this scenario, we would expect positively correlated trends in productivity across trophic levels. In this study, we utilized 40 years of data from the Farallon Islands to examine recent contrasting trends in productivity (chicks fledged per breeding pair) between the piscivorous Brandt's Cormorant (*Phalacrocorax penicillatus*), and Cassin's Auklet (*Ptychoramphus aleuticus*), a zooplanktivore. We calculated sliding correlations of lengths 5 to 17 years and created a color contour plot to show that a distinct change in the relationship between the productivity of these two species occurred in the late 1990s: productivity was initially strongly positively correlated then became increasingly negatively correlated. We then used Generalized Additive Models (GAMs) to determine which of seven oceanographic variables (including local and basin scale measures) are best able to predict productivity before and after 1999. We found the physical variables predicting productivity of Brandt's Cormorants did not change much over time while there was a distinct change for Cassin's Auklet. Winter values of the North Pacific Gyre Oscillation (NPGO) have become the dominant predictor of Cassin's Auklet productivity. NPGO variability is related to the Central Pacific Warming type El Niño which is becoming more frequent and more intense. This change in the physical driver behind Cassin's Auklet productivity may be responsible for the apparent deviation from a purely bottom-up structure.

#### KLEPTOPARASITISM IN A LARGE COLONY OF COMMON MURRES AT CASTLE ROCK NATIONAL WILDLIFE REFUGE IN NORTHERN CALIFORNIA

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Kleptoparasitic feeding behaviors, particularly during chick-rearing, can occur between Common Murre (*Uria aalge*) at breeding colonies. However, there have been very few reports of intraspecific kleptoparasitism among murres, indicating that this behavior is either rare or challenging to document with traditional observational methods. Use of remotely-controlled video cameras resulted in the observation of kleptoparasitic interactions among murres during 18% of 625 prey deliveries during chick-rearing in 2009, with the thief being successful 38% of the time. Based on prey types that were involved four or more kleptoparasitic interactions, thieves kleptoparasitized prey based on availability rather than preferentially selecting a specific prey type. These interactions were brief, occurring over a period that averaged  $5.7 \pm 1.7$  seconds. Kleptoparasitism was more likely to be attempted if prey items were visible for longer, the distance between prey-owners and neighbors decreased, and a greater number of older chicks were present at the colony. Attempted thefts were more likely to be successful when multiple individuals participated in the attempt to steal and when a greater number of chicks were present at the colony. At Castle Rock in northern California, intraspecific kleptoparasitism was prevalent probably due to limited prey availability and low energy per prey delivery which caused low co-attendance among chick-rearing murres at this colony. Kleptoparasitizing conspecifics at the colony would enable a thief to provision their

chick without leaving the colony, minimizing the time that their chick was unattended and consequently reduced the risk of starvation, predation, and conspecific attack for their chick.

## MARINE BIRDS OF YAKUTAT BAY, ALASKA: EVALUATING ABUNDANCE, DISTRIBUTION AND THREATS AT SEA

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Despite being remotely located, Yakutat Bay, Alaska hosts human activities that pose potential threats to marine birds, including species of conservation concern: Red-throated Loon (*Gavia stellata*), Yellow-billed Loon (*G. adamsii*), Aleutian Tern (*Sterna aleutica*), and Marbled (*Brachyramphus marmoratus*) and Kittlitz's murrelet (*B. brevirostris*). We estimated marine bird distribution and abundance by conducting systematic at-sea surveys in Yakutat Bay on 17–22 June 2009 (n=33 transects), and compared our results with a similar survey in June 2000. We then identified the incidence and location of anthropogenic actions that may stress/threaten birds and analyzed their overlap with bird distributions. All species of concern were more abundant in 2009 except Yellow-billed Loons, which were not observed in our study. Additionally, in 2009 species richness (mean no. species/km surveyed±SE; 1.30±0.16 species) and overall bird abundance (mean no. birds/km±SE; 5.78±0.80 birds) were greater than in 2000 (0.77±0.13 species; 4.18±1.00 birds). Based on their natural history, pursuit-diving birds, especially Marbled and Kittlitz's murrelets, are at greatest risk to the stressors and threats evaluated in this study. Gillnet fishing overlapped with 3.4% of observed pursuit-diving birds, including 3.8% of Marbled and 2.4% of Kittlitz's murrelets, and 7.2% of surface-seizing birds. Vessel traffic overlapped with 8.3% of observed Marbled and 14.6% of Kittlitz's murrelets. Oil spills were not reported in our study area; however, they remain a potential threat to marine birds. This type of analysis could be used to assess threats to Marbled and Kittlitz's murrelets elsewhere in their range, and contribute to their conservation.

## TROPHIC ECOLOGY OF TROPICAL SEABIRDS: WHAT DO WE KNOW AND WHERE DO WE GO FROM HERE?

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In the Pacific, trophic relationships of tropical seabirds have been the focus of study on and off for the last 50 fifty years. Early on these studies principally employed traditional diet analysis of seabird



regurgitation, and have since advanced to the application of more recent techniques; e.g., the use of stable isotopes technology. Our current understanding of tropical seabird trophic relationships is rooted in these historical studies. What is currently known is reviewed here but discussed in the framework of new approaches and technologies, and in regards to current resource stewardship and societal concerns. For example, can our understanding of tropical seabird feeding habits and resource partitioning help us to apply ecosystem-approaches to resource management and conservation (e.g. spatial planning), to assess and monitor impacts due to climate change or marine pollution (e.g., marine debris, plastics, etc.) effects, or to mitigate fisheries interactions? What has really changed with this field is the end game; the next step opportunities and application of seabird trophic ecology information to benefit the broader community interests.

## HABITAT USE OF PAPA HĀNAUMOKUĀKEA MARINE NATIONAL MONUMENT WATERS BY TWO SYMPATRIC BOOBY SPECIES

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The Papahānaumokuākea Marine National Monument (PMNM) is one of the largest marine sanctuaries in the world and one of its central objectives is to protect at-sea habitat of seabirds within monument waters. However, the effectiveness at protecting critical or even important habitat has not been fully evaluated because limited information exists about the foraging behavior of most seabird species that the PMNM could protect. Here, we present data showing the habitat use of two booby species that breed sympatrically at Tern Island, French Frigate Shoals, Northwest Hawaiian Islands. During the winter/spring of 2009 and 2010, we recorded the foraging behavior of 37 red-footed (*Sula sula*) and 44 masked (*S. dactylatra*) boobies using GPS data loggers attached to 3-4 tail feathers. All boobies foraged at sea during daylight hours so maximum ranges from the colony were less than 150 km. A pronounced segregation was evident where red-footed boobies foraged southwest of Tern Island and masked boobies foraged northwest. Both species did overlap while foraging around Brooks Bank, west of Tern Island. Although approximately 60% of time at sea for red-footed boobies was spent within monument waters, key foraging habitat based on bird behavior occurred outside monument boundaries. In contrast, approximately 85% of time at sea for masked boobies was spent within monument boundaries, where most foraging activity occurred. These data reveal mixed results about the putative protection that PMNM has for boobies but clearly more species (and interspecific interactions) need to be studied before effectiveness can be adequately judged.

## IS IT STILL A BIRD EAT BIRD WORLD? HOW PENGUIN DECLINES MAY IMPACT BROWN SKUAS BREEDING ON KING GEORGE ISLAND

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The purpose of this study was to assess the fish component in the diets of brown skuas (*Catharacta lonnbergi*) breeding on King George Island. The Antarctic Peninsula region has recently experienced declines in ice extent and duration associated with warming temperatures. There has been a concomitant decline in the Adélie penguin (*Pygoscelis adeliae*) population. With the decline in numbers of breeding Adélie penguins, we hypothesized that brown skuas may change their diets from penguin chicks and eggs to rely more on fish. We collected approximately 75 guano samples each season from around brown skua nests in 2007 and 2008 and assessed the frequency of occurrence of fish (otoliths, bones, lenses) and penguin remains (eggshells, bones, feathers). We found that the frequency that fish occurred in the samples varied from 21% (2007) to 51% (2008) whereas the proportion containing evidence of penguin remains was approximately 78% in both years. We assessed the size of the fish consumed based on otolith length and width measurements from otoliths recovered from four breeding seasons (2005 to 2008). We found that brown skuas consumed *Pleurogramma antarcticum* that were on average 17 g and 132 mm (n=155) and *Electrona antarctica* that were 7 g and 78 mm (n=175). The frequency of *E. antarctica* was highest in 2008 (62% of fish consumed) whereas the frequency of *P. antarcticum* was highest in 2007 (56%). This study will serve as a baseline to assess future shifts in diets of brown skuas in response to climate change.

#### HABITAT PARTITIONING OF SEABIRD FORAGING GUILDS IN THE NORTHERN GULF OF ALASKA IN RELATION TO WATER MASSES AND ZOOPLANKTON BIOMASS

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Data are presented on the cross-shelf distribution and abundance of seabird foraging guilds in northern Gulf of Alaska (GOA), and related to patterns in water mass properties and zooplankton species composition and biomass. At-sea surveys were undertaken to collect data on seabird abundance, zooplankton biomass and water mass properties (salinity and temperature) during winter (March) and early spring (April) from 2000 to 2003 in the northern GOA. Three zones (inner, middle and oceanic domain) were identified by mean salinity and overall zooplankton biomass, the latter of which increases from the inner shelf to the outer shelf. Highest density of divers, the most abundant seabird foraging guild throughout the study, occurred in the middle zone. Surface feeders were most abundant in the middle zone and oceanic domain, and surpassed the abundance of divers on only two surveys, when northern fulmars were the most abundant surface feeder. Murre abundance was positively correlated with the biomass of euphausiid *Thysanoessa inermis*, and northern fulmars were associated with cephalopod paralarvae and the oceanic copepod *Eucalanus bungii*. Elevated biomass of *Thysanoessa inermis* in March and April may be an important factor influencing habitat choice of wintering murre in the northern GOA.

#### WINTERING DISTRIBUTIONS OF VULNERABLE MARINE BIRD SPECIES IN THE GULF OF MEXICO, 2011

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The explosion of the semi-submersible offshore oil drilling rig 'DeepWater Horizon' in April 2010 and subsequent oil spill in the Gulf of Mexico highlighted a serious lack of data on the offshore distributions of marine birds in the region. The extended duration of the spill (5 months) and massive quantities of oil (>200 million gallons) and chemical dispersant discharged (>3 billion gallons) have the potential to impact both year-round resident and migratory marine bird species in the Gulf of Mexico. Of species for which more than 100 individuals were collected during or recovered since the oil spill, the top three are Laughing Gull (*Larus atricilla*), Brown Pelican (*Pelecanus occidentalis*), and Northern Gannet (*Morus bassanus*). Laughing Gulls and Brown Pelicans are year-round residents, while Northern Gannets are wintering migrants from breeding colonies in eastern Canada. The marine habitats occupied by all three of these species include areas where oil slicks and weathered by-products persisted in the environment throughout the winter of 2010-11, presenting a potential hazard to these species. From mid-February to mid-March, 2011, we conducted standard offshore, boat-based surveys spanning the western half of the Gulf of Mexico, from Mobile Bay, Alabama, to Terrebonne Bay, Louisiana. We present a 'first cut' GIS analysis of the distributions of these three vulnerable marine bird species in relation to the oil-impacted area.

#### SEASONAL PROGRESSION OF PREY SIZE AND COMPOSITION OF ELEGANT TERN (*THALASSEUS ELEGANS*) CHICK PROVISIONING IN SOUTHERN CALIFORNIA: A TEST OF CENTRAL-PLACE FORAGING

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The Elegant Tern (*Thalasseus elegans*) is expected to be a central-place forager. Central-place foraging theory states that an animal will preferentially acquire food close to its nesting area and will travel far away from the colony only when nearby food supplies are depleted and then bring back larger, more energy-dense prey and that foraging distance is limited by the need to return to the breeding area. Seasonal variation in diet reflects the changing availability in prey items in the foraging habitat, spatially and temporally. When prey availability is poor, some seabirds will increase the length and duration of foraging trips, which can have negative effects on chick growth. We used dietary data from 1994-2009 to assess the degree to which the Elegant Terns at Bolsa Chica Ecological Reserve (BCER) follow a central-place foraging lifestyle. We looked at the seasonal variation in the prey composition brought back to the nesting site as well as average prey size across the season. Preliminary results show that Elegant Terns do not follow the typical central-place foraging pattern. During the 2004 season, the average prey size during the first two weeks was 106.0 mm compared to 76.3 mm during the last two weeks (p-value = 0.02, one-tail t-test). During the next breeding season (summer 2012), we will be using GPS units to track the foraging behavior of Elegant Terns at BCER to determine the distance travelled from the colony as well as the location where each prey item was captured.

#### SEABIRDS IN THE NEAR-SHORE CALIFORNIA CURRENT: AN UPDATE FROM OREGON COASTAL WATERS.

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Patterns of seabird abundance and distribution during summer within 5 km of shore are analyzed over a 20 year time series to delineate important geographic areas and assess change in abundance and diversity. Density of most species was highest within 1 kilometer of shore, with persistent latitudinal concentrations near colonies and around Cape Blanco. Foraging ‘hotspot’ locations were variable within and across years. Near-shore sea surface temperature patterns showed trends indicating reduced local upwelling and delay in seasonal transition of oceanographic periods in recent years. Seabird trends varied by species, but overall composition was consistent and not closely linked to the physical parameters measured.

#### ALBATROSS POST-BREEDING “HOTSPOTS”: OPTIMAL FORAGING AREAS OR MOLTING AREAS...OR BOTH?

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Albatrosses are well-known for making repeated long-distance flights, often crossing entire ocean basins throughout the breeding and non-breeding season. The summer, non-breeding season, however, is also a period when North Pacific albatrosses (*Phoebastria* spp.) molt varying numbers of flight feathers. Because flight efficiency of large-bodied albatrosses can be dramatically compromised during molt, individuals may theoretically seek regions of higher wind speed to compensate for reduced gliding efficiency. Alternatively, individuals could seek regions offering high foraging efficiency irrespective of wind speed. During post-breeding satellite tracking and at-sea capture studies of albatrosses in Alaska, we found evidence to support the latter - use of relatively low wind speed, yet highly productive, areas during molt. Evidence included: (1) extended periods of localized movement at sea, e.g., spending weeks within a 100 km radius, (2) extensive flight feather molt, and (3) occurrence in regions of relatively low wind speed. Furthermore, some of these “hotspots,” or high use areas, were frequented by many individuals. Several of these “hotspots” occurred within passes of the Aleutian Archipelago, which are known to be very productive feeding areas for marine organisms. Furthermore, diel tidal influence causes reversing current directions within passes where albatrosses could nearly act as passive drifters while remaining within productive feeding grounds and, indeed, some tracks resemble such movements. We suggest that albatrosses may use specific “molting areas” when undergoing more extensive flight feather replacement. These results have important implications for understanding the post-breeding season ecology of albatrosses and the conservation of important at-sea habitats.

#### A SYNCHRONIZED SENSOR ARRAY FOR REMOTE MONITORING OF AVIAN AND BAT INTERACTIONS WITH OFFSHORE RENEWABLE ENERGY FACILITIES

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In contrast to land-based wind facilities, animal casualties in off-shore wind energy installations can only be efficiently assessed over the long term using an on-board detection system with data transmitted remotely to shore-based data processing centers. Our goal is to design, test, and deploy an

integrated sensor array that will continuously monitor interactions (including impacts) of avian and bats on blades, nacelle and tower of wind turbines. We propose to develop a synchronized array of sensors including accelerometers, visual and infrared spectrum cameras, and acoustic monitors. On-board, custom-designed data post-processing and statistical-based algorithms will detect impacts from other disturbances and trigger the event recording. The task of the post processing algorithms is to generate a trigger event for each impact above a certain energy level. The monitoring system will be designed to run continuously and at several turbines in parallel. Remote access to the recorded images and sensor data will make it possible to quantify interactions, including collisions, and identify organisms involved to the lowest taxonomic grouping possible. This 3 year technology development project will include laboratory and controlled field testing of the sensor array. The development phase will conclude with full scale testing of experimental strike and near-strike events on a research wind turbine at the National Renewable Energy Laboratory in Colorado. Once completed, deploying low cost sensor arrays will be instrumental during site assessment for proposed offshore facilities and in monitoring established wind farms to inform impact model assessments.

#### FACTORS AFFECTING CONTAMINANT BURDENS IN FISH-EATING BIRDS AND THEIR PREY FROM A MAJOR NORTH AMERICAN ESTUARY: POLYCHLORINATED BIPHENYLS (PCBs) IN THE COLUMBIA RIVER ESTUARY

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We evaluated PCB levels in eggs and chicks of Caspian Terns (*Hydroprogne caspia*), Double-crested Cormorants (*Phalacrocorax auritus*), and their prey fish from the lower Columbia River estuary, where these species nest in large numbers and PCB contamination has been a wildlife conservation concern. For comparison, samples were also collected at colonies in the upper estuary and on the mid-Columbia River. PCB levels in cormorant eggs from a colony in the upper estuary were the highest among sampled species/colonies. PCB levels in livers of cormorant chicks from the upper estuary, as well as terns from the mid-Columbia River, were the highest. Based on differences in tern and cormorant diet composition, as determined by conventional stomach and bill load analyses and carbon stable isotope ratios, higher PCB levels in eggs and chick livers were associated with diets dominated by resident freshwater and estuarine fishes. Trophic level, as indicated by nitrogen stable isotope ratios, did not explain a significant proportion of differences in PCB levels among bird species/colonies or prey fish. PCB levels in prey fish were positively correlated with their lipid content; however, PCB levels in chick livers were negatively correlated with chick fat scores, suggesting that nestling fat reserves can serve as a PCB sink. Lower PCB levels in terns and cormorants from colonies near the mouth of the Columbia River, compared to those from colonies further up-river, reflected diets with a higher proportion of marine forage fishes, which had lower PCB levels than resident freshwater and estuarine fishes.

## THE STATUS AND CONSERVATION OF SEABIRDS IN THE OGASAWARA ISLANDS, JAPAN

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Sea bird diversity is remarkable in the Ogasawara islands (center N27°59', E141°33', subtropical zone) that are consisted by about 30 small islands. Currently, a total of 16 species (*Phoebastria immutabilis*, *P. nigripes*, *Pterodroma hypoleuca*, *Bulweria bulwerii*, *Puffinus pacificus*, *Puffinus lherminieri bannermani*, *Oceanodroma tristrami*, *O. matsudairae*, *Phaethon rubricauda*, *Sula leucogaster*, *S. dactylatra*, *S. sura*, *Thalasseus bergii*, *Sterna fuscata*, *Anous stolidus* and *A. minutus*) was recorded breeding in the islands based on the field and literature surveys. *O. matsudairae* and *P. lherminieri bannermani* are endemic breeders in the islands.

The distribution of breeding sites may be affected by human settlement and alien mammals such as feral goats, black rats, and feral cats. A case of massive predation on small petrels, *B. bulwerii*, by black rats has been detected in the small islands off Chichijima in 2006. Eradication programs on these alien mammals have commenced in the part of islands gradually. On the islands of alien mammals eradicated, small and medium petrels start to recolonize.

Because of overexploitation in the 1930's, albatrosses were locally extinct (*P. albatrus*) or diminished (*P. nigripes*). The population of *P. nigripes* have expanded gradually since the 2000's (about 1000 pairs), however the population of *P. immutabilis* remained same (about 20 pairs). The re-colonizing program on *P. nigripes* has started since 2005.

## CONSERVING SEABIRDS BY ENFORCING FEDERAL LAW

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For over 30 years, the citizens of Kauai have employed a noble and novel program to retrieve and release tens of thousands of grounded Newell's shearwaters, Hawaiian petrels and other nocturnally active seabirds that are susceptible to light attraction or striking utility lines. The program served to educate the community about the plight of their endemic seabirds—a significant conservation achievement. However, the community has collectively failed to adequately address the causes of seabird groundings, and failed to reverse population declines despite extensive research, population monitoring, conservation status assessment and classification, and annual outreach. The societal changes necessary for conserving endemic, mountain-nesting seabirds are only now being realized on Kauai, and elsewhere in Hawaii, due to the active and strategic enforcement of federal (US) laws intended to protect wildlife. Strategic application and enforcement of these laws has recently secured binding commitments from private and public entities toward proactive compliance with State and federal laws through the expenditure of millions of dollars over the next several years to reduce the incidental take of these species and to comprehensively conserve them on an island-wide basis by: altering utility lines, shielding and otherwise managing outdoor lights, improving the retrieval and rehabilitation of grounded seabirds, funding additional research, educating the public about the cultural and ecological significance of the

birds and, most importantly, conducting predator control and other management activities in seabird colonies.

## GIVING VOICE TO SEABIRDS IN URBAN HONOLULU THROUGH LAW ENFORCEMENT

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White terns (*Gygis alba*) and wedge-tailed shearwaters (*Puffinus pacificus*) both regularly breed in urban Honolulu, Hawaii, but suffer at the hands of humanity despite being protected by State and federal laws. Factors negatively affecting these species stem from a tradition of failure to enforce these laws which, in turn, has contributed to poor public appreciation of their existence, natural history, ecological value and cultural value. The U.S. Fish and Wildlife Service's Office of Law Enforcement has employed a variety of tactics to improve conditions for these species in Honolulu, including traditional law enforcement as well as novel approaches toward public outreach, focused training of State Conservation Officers, and proactive contacts with key groups such as tree trimmers and developers. As a result of these efforts, the white tern has been designated as the official bird of the City and County of Honolulu, and collaborative efforts by others resulted in creation of a privately owned and managed seabird preserve in urban Honolulu. Additionally, because of these species' relative tolerance to disturbance, paths toward co-existence with humans in the urban environment have been elucidated. Tree trimming and urban construction can proceed in manners that do not legally harm these birds and may be performed in manners that accommodate and even foster their continued presence.

## META-ANALYSIS OF SEABIRD-CLIMATE RELATIONSHIPS

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Being globally distributed and arguably the most conspicuous marine organisms living at the interface of the atmosphere and the ocean, seabirds have been well-studied in many high and some low latitude marine ecosystems. In this paper, we present a synthesis of results obtained from analysis of a unique seabird-climate meta-database. Based upon published 91 studies encompassing 95 species from 24 oceanic regions and integrating 2,599 records (mostly correlations) of seabird parameters with ocean climate variables such as SST, sea ice extent (SIE), thermocline depth, etc., we investigate whether climatic relationships with seabirds vary or are similar between ecosystems, habitats, or species, and whether any systematic relationships, e.g., positive correlations with SST on the western side of ocean basins and negative correlations in the east) can be established. We found inconsistent relationships with SST (both positive and negative), but relatively consistent relationships with SIE (positive, more generally better), and that in most cases seabird-climate relationships were indirect, mediated through changes in prey fields. Most seabird-climate relationships were non-linear, but that only through synthesis of multiple population responses were non-linearities be revealed. We also identify "hotspots" of seabird-climate studies (e.g. NE Atlantic), and where there are serious deficiencies in methods and understanding (e.g., dealing with serial autocorrelation, mechanisms).



## CONSERVATION OF SEABIRDS AND THE MARINE ENVIRONMENT IN “THE SEA OF MIRACLES.”

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The Seto Inland Sea of Japan has only 21% of its natural coastal habitats left due to industrial development since the 1960s. Near the west end, Kaminoseki, known as “The sea of miracles,” has escaped most development with 75% natural coastal habitats, traditional biodiversity, and small towns long dependent on local ocean environments. Since 1982, a nuclear power plant has been targeted for this area, with little support from the local people. Since 1999, the Nagashima Nature Conservation Association has conducted biological surveys in this area, in collaboration with the Ecological Society of Japan, Japanese Association of Benthology, and the Ornithological Society of Japan. We have found important feeding habitats for Japanese Murrelets (*Synthliboramphus wumizusume*; IUCN Vulnerable) and the only breeding colony of Streaked Shearwaters (*Calonectris leucomelas*; Japan near endemic) in the Seto Inland Sea. In addition, other rare species include: Finless Porpoise (*Neophocaena phocaenoides sunameri*; Vulnerable); Japanese Lancelet (*Branchiostoma belcheri*); a newly described rare gastropod (Genus *Ceratia*); and Japanese Wood Pigeon (*Columba janthina*; Near Threatened). We seek to permanently stop construction of a nuclear power plant initiated in 2010 but currently suspended after the 2011 Fukushima disaster. Our primary concerns are: (1) preventing extinction or local extirpation of rare species during reclamation of subtidal environments; and (2) preventing destruction of valuable feeding habitats for rare seabirds and marine mammals due to warm wastewater with radioactive contamination. We aim to register this area as an UNESCO sanctuary to protect rare species and maintain sustainable small towns.

## UNTANGLING THE CONFOUNDING FACTORS AFFECTING HUMAN-SEABIRD INTERACTIONS

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The challenge of addressing disturbance to breeding seabird colonies is confounded by the dynamic environment we live in. Biotic and abiotic factors have the potential to influence human-seabird interactions, which then can influence breeding success and productivity.

The Seabird Protection Network (the Network) is a multi-organization collaborative that aims to restore and protect seabird populations harmed by the 1998 *Command* Oil Spill and the *Luckenbach* mystery spill. Restoration funds from these spills are being used to address one of the biggest obstacles to the recovery of seabird populations: human disturbances. The goal of the Network is to reduce human disturbances at seabird breeding and roosting sites from Point Reyes to Point Sur along the central California coast, a region with the largest concentration of breeding seabirds in the contiguous United

States. Increased public awareness, coupled with coordinated management, enforcement and strategic partnerships, is essential to effectively protect seabirds from negative human interactions.

Assessing the effectiveness of outreach efforts can be challenging and often burdensome. Adding to the challenge are the dynamics of society – gas prices, income levels and recreational or subsistence need for ocean resources – all of which can affect human activity and the success and/or failure of the Network. Additionally, environmental variables play a role in assessing the effectiveness of the project. By using the framework established through Ecosystem Based Management, the Network is seeking to utilize tools to help determine critical variables to better assess the success and/or failures of the efforts of the Seabird Protection Network. For example, weather can affect both an individual's actions and abilities to approach seabird colonies as well as the breeding success and productivity of seabird populations.

#### A NORTH WESTERN PACIFIC METRIC OF PELAGIC MARINE DEBRIS: PLASTIC INGESTION BY BLACK-FOOTED ALBATROSS FROM KURE ATOLL, HAWAII

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Black-footed (*Phoebastria nigripes*) Albatross ingest plastic at sea, which they deliver to their chicks on breeding colonies. We characterized the amounts and types of ingested plastic using regurgitated boluses (n = 25 in 2008 and 2009) on Kure Atoll, the westernmost Hawaiian colony. These analyses yielded information on the volume and mass of four plastic types (fragments, line, sheets, foam) and three natural item categories (squid beaks, other food, other non-food). The mass and volume of these categories were significantly correlated ( $p < 0.001$ ), with different slopes indicative of their varying densities. A comparison of the bolus composition across years revealed that only the proportional mass of sheets was different (higher in 2008,  $p < 0.001$ ). Combining years, plastic composed 62.8% and 27.1 g of the bolus mass, with the following relative plastic composition: line (45.0% and 11.9 g), foam (30.8% and 8.8 g), fragments (19.7% and 5.3 g), and sheets (2008; 5.1% and 1.2 g, 2009; 3.4% and 0.9 g). To characterize albatross foraging areas, we tracked seven albatross with Argos transmitters in May-June 2008. These birds completed 15 foraging loops west of their colony, and foraged over oceanic waters and seamounts, where they spent 65.5% (9.73%SD) and 9.2% (3.51%SD) of their time, respectively. These results underscore the use of albatross as bio-sensors of pelagic plastic and suggest high levels of marine debris in the western North Pacific.

#### TERRESTRIAL HABITAT SUITABILITY MODELING FOR NEWELL'S SHEARWATERS ON KAUAI

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Newell's Shearwater (*Puffinus newelli*), or 'A'o, is endemic to the main islands of the Hawaiian Archipelago and identified as endangered under the IUCN Red List. Newell's shearwaters have experienced a significant population decline during the past two decades, including a breeding range contraction on the island of Kaua'i, the last stronghold of the species. Identifying the complete distribution of colonies on Kaua'i is a critical management step for assessing conservation status and prioritizing management activities, but is hindered in practicality because of steep terrain and remote access. We developed a terrestrial habitat suitability model using Principal Components Analysis (PCA), logistic regression, and a Geographic Information System. We modeled abiotic (wind speed, soil depth, slope, aspect), biotic (% vegetation type, % native vegetation) and anthropogenic variables (viewable light, distance to nearest road) against the locations of known colonies. Our model suggests that a large portion of Kauai could be suitable habitat for nesting by Newell's Shearwater although much of the habitat appears unoccupied. When combined with information on anthropogenic threats, our habitat model identified the mountains on the north-central and north-west regions of Kaua'i as an ideal location for future surveys and possible reintroductions because of their physical isolation from anthropogenic disturbance.

#### POTENTIAL EFFECTS OF OFFSHORE WIND POWER STATIONS ON SEABIRDS IN JAPAN

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Renewable energy has been strongly promoted in Japan to help prevent global warming, which has received increasing attention particularly after the Fukushima nuclear disaster in March 2011. Due to the declining number of suitable construction sites on land, as well as better wind conditions along the coasts, offshore wind power is now being considered very actively. The construction of offshore wind power stations is expected to accelerate after the introduction of the Feed-in Tarrif (FIT) in July 2012. Such circumstances threaten to promote and implement the construction of such power stations without sufficient knowledge of their impact on marine ecosystems, particularly seabirds. Furthermore, there has been little experience with the construction of wind power stations in Japan, and evaluation methods for Environmental Impact Assessment (EIA) have not yet been established. We therefore chose the southern coastal areas of Nemuro Peninsula, Hokkaido as a model, because the region is included in the Ministry of the Environment of Japan's map of potential sites for construction of offshore wind power stations and is also considered to be an important habitat for seabirds. We investigated the current status of seabird populations, in order to provide baseline data for future evaluation of the impact of environmental influences. We report preliminary results of species composition, distribution, density and height of flight of seabirds in the region and discuss evaluation methods of the impact of offshore wind power stations on marine ecosystems and biodiversity.

## MERCURY AND ORGANIC CONTAMINANTS IN LAYSAN ALBATROSS (*PHOEBASTRIA IMMUTABILIS*) EGGS COLLECTED FROM HAWAI'I IN 2010

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The Seabird Tissue Archival and Monitoring Project (STAMP) began collecting and banking seabird eggs in 1999. The goal of STAMP was to monitor long-term trends in environmental quality by (1) collecting eggs at Alaskan seabird colonies without inadvertently contaminating them, (2) processing and banking the samples under conditions that ensure chemical stability during long-term (decadal) storage, and (3) analyzing subsamples of the stored material for anthropogenic contaminants. In 2010, the 111<sup>th</sup> Congress provided funding to NIST to expand its capabilities and resources into the Pacific region through a Pacific Islands specimen banking component that includes biorepository storage capabilities for the region. To begin this effort, STAMP collected 43 Laysan Albatross (*Phoebastria immutabilis*) eggs from Oahu and Kauai in 2010. The eggs were fresh homogenized at HPU, aliquoted and shipped to NIST's Marine Environmental Specimen Bank in Charleston, SC for long-term storage. An aliquot of each egg was analyzed for mercury (Hg) and organochlorine contaminants (with additional aliquots available for future research). The Albatross eggs had higher levels of Hg, polychlorinated biphenyls (PCBs), 4,4'-DDE, oxychlordane and mirex than the Alaskan Murre (*Uria* spp.) eggs, but lower levels of the more volatile organochlorine pesticides. Within the Albatross eggs, there were little differences in contaminant patterns, but the eggs collected from the North Shore of Kauai generally had lower levels of most contaminants. Future STAMP expansion will include six additional seabird species from Hawai'i and other U.S. Pacific Islands based on results of a workshop held with various partners in 2011.

## PREDATOR CONTROL ALLOWS GROWTH OF A RED-TAILED TROPICBIRD COLONY ON OAHU

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Introduced mammalian predators are the most serious threat to many island-nesting seabirds and have caused the extinction and local extirpation of many island species. The Red-tailed Tropicbird (*Phaethon rubricauda*) is a widespread tropical seabird of the Pacific and Indian oceans but has a relatively small global population. This species is common in the Northwestern Hawaiian Islands, but in the main Hawaiian Islands it is restricted to a just few locations and its numbers are limited by introduced predators. We monitored a colony of Red-tailed Tropicbirds in southeastern Oahu from 2005-2011, and

we controlled rats (*Rattus* spp.), mongoose (*Herpestes auropunctatus*), and feral cats using a combination of traps and bait stations. Nest success was low in 2005 but increased immediately following the initiation of predator control in 2006. The colony has grown at 14% per year, from 19 nests in 2006 to 36 in 2011, and the number of chicks fledged has increased from 5 in 2005 to 26 in 2011. The average incubation period was 44.2 days and the average nestling period was 81.6 days. Overall nest success with predator control was 58%. This study demonstrates that seabirds can thrive on inhabited islands if introduced predators are controlled. High islands like Oahu are likely to become increasingly important to tropical seabirds as global climate change causes inundation of colonies on low-lying atolls. Protecting colonies on high islands can provide safe alternative nesting sites for displaced birds and reduce the impact of climate change.

#### ASSESSING RISK FACTORS FOR DECLINING MARINE BIRDS IN THE SALISH SEA: CAN COMMONALITIES INDICATE DRIVING MECHANISMS?

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The Salish Sea faces an increasing rate of local extinctions in its wildlife. Most of these extinctions will be the direct result of either fisheries or cascading effects of ecosystem deterioration in the face of human disturbance. Marine birds, because of their natural history (long-lived, migratory apex predators), can be key indicators of ecosystem health and therefore flagship species for the conservation of the Salish Sea. We therefore used survey data from marine bird monitoring programs in both the United States and Canada to assess temporal and spatial trends in species composition for dominant bird species of the Salish Sea during the last 17 years. We found non-random changes in species dominance for several species, suggesting that particular species are more likely to become locally extinct in the Salish Sea than others. We then used a risk assessment model to gauge commonalities amongst declining species, and therefore gain a better understanding of the mechanisms driving declines of marine birds in the Salish Sea. We hypothesize that species that are obligate piscivours are more likely to have population decreases in Puget Sound, and that species compositions are changing accordingly. Our research can be applied to identify management and conservation strategies that will positively impact multiple species and encourage ecosystem-level recovery in Puget Sound.

#### A NEWLY DESCRIBED SEABIRD DIVERSITY HOTSPOT IN THE DEEP NORTHWEST ATLANTIC IDENTIFIED USING INDIVIDUAL MOVEMENT DATA

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Pelagic seabirds are one of the most widely distributed, far-ranging and endangered groups of animals. Recent and emerging threats include over-fishing, bycatch and climate change. In order to quantify and mitigate these hazards it is necessary to understand the drivers of seabird distribution. While these have been investigated extensively in neritic waters and parts of the Southern and Pacific Oceans, surprisingly little is known about their effects in the deep North Atlantic. We therefore used tracking data from 20 species, representing 47 populations of North Atlantic breeders and southern hemisphere migrants, to quantify the mesoscale diversity and relative abundance of seabirds within the region. These data revealed a hitherto undescribed usage hotspot approximately 1000,000 km<sup>2</sup> in extent in waters >3000 m deep between the Grand Banks and the Mid-Atlantic Ridge (MIR), south of the Charlie Gibbs Fracture Zone (CGFZ). This area was used by 17 species during one or more key life history stages. Despite considerable variability within individuals, populations and species, the hotspot persisted throughout the year, its location coinciding with the sub-Polar Frontal zone. We hypothesise that within this complex ecotone, currents topographically constrained by the MIR and CGFZ cause intense mesoscale turbulence and large-scale habitat heterogeneity, leading to high diversity and, in some cases, abundance of seabirds. The hotspot is also used by other wide-ranging megafauna, including bluefin tuna (*Thunnus thynnus*), which are targeted by a burgeoning longline fishery. Given the threat such activities pose, we suggest that the hotspot should be declared a Marine Protected Area.

#### WANTED: DEAD OR ALIVE? HAWAIIAN ALBATROSSES FEED MAINLY BY SCAVENGING ON MESOPELAGIC CEPHALOPODS

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In a previous diet study, based on regurgitation samples from Laysan albatross (*Phoebastria immutabilis*, LAAL) and Black-footed albatross (*Phoebastria nigripes*, BFAL) breeding on the Hawaiian Leeward Islands, Harrison *et al.* (1983) concluded that these species fed primarily on vertically-migrating cephalopods that were caught alive at the surface at night. However, in a more recent study, based on cephalopod beaks identified from LAAL chick regurgitation pellets collected on Guadalupe Island, Mexico, it was concluded that most of the cephalopods were mesopelagic species that were probably scavenged during the daytime (Pitman *et al.* (2004). To address these contradictory results we located and identified a large series of previously unidentified cephalopod beaks from the Harrison *et al.* study. A total of 3,343 beaks from 59 LAAL and 68 BFAL samples were identified. Results revealed evidence for a much different feeding strategy than was presented in the original study in that both species of birds were feeding primarily on a wide range of species of adult stages of mesopelagic cephalopods. Based on the



vertical distribution and movements of the dominant species of cephalopods identified, we again conclude that these two albatross species are primary diurnal scavengers instead of active nocturnal predators.

## PRELIMINARY RESULTS ON THE DIETS OF LAYSAN AND BLACK-FOOTED ALBATROSSES AND THE USE OF FISHERIES BY-CAUGHT MARINE BIRDS IN INVESTIGATIONS OF NATURAL FEEDING STRATEGY

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Stomach contents from Laysan and Black-footed albatrosses collected by NMFS fisheries observers in longline fisheries in the eastern Bering Sea, Gulf of Alaska and Hawaiian regions during the 2005 to 2010 period were available for study. Food item remains from 115 Laysan (*Diomedea immutabilis*) and 58 black-footed albatrosses (*D. nigripes*) were identified. This study revealed that commercial fisheries related food items such as longline bait and discarded catch remains (offal) were readily separable from the remains of naturally occurring prey. Though the dietary composition of the birds is undoubtedly altered by the concentration of available food generated by fisheries activities, the large sample size of birds examined and the incidence of naturally occurring prey items provide valuable information about what the birds feeding strategy would be like in the fisheries absence. Naturally occurring food items identified in this study indicate that, while both species of birds engage in some feeding on small fishes at the surface, they rely primarily on scavenging on dead or moribund mesopelagic squid as a natural feeding strategy.

## BLACK-CAPPED PETREL CONSERVATION IN HISPANIOLA

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The Black-capped Petrel (*Pterodroma hasitata*) historically nested at many sites throughout the Caribbean, but deforestation, human hunting pressure and predation have reduced the distribution to three remote sites on Hispaniola. The current global population is estimated at as few as 1000-2000 pairs (Lee 2000). The Conservation Action Plan for the Black-capped Petrel (2011) identifies the discovery of new nesting sites as the top conservation research priority for the bird. In the 2010/2011 breeding season, a new nest was discovered on Morne Vincent, Massif de la Selle, Haiti, which yielded the first detailed breeding information on the species. Monitoring continued in 2011/2012. This nesting location appears to be highly threatened by agricultural expansion, invasive mammals and direct harvest by local residents. In January of 2012, we used two advanced technologies that have not been available to petrel researchers until now. We used a night-vision system combined with an accurate portable radar system to identify

additional nesting sites, to obtain more precise population estimates at known nesting sites at Lomo del Toro in the Sierra de Bahoruco National Park.

## SPATIAL UTILIZATION PATTERNS OF SHORT-TAILED SHEARWATERS DURING THE BREEDING AND NONBREEDING SEASON

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Long-distance migrating seabirds may change their spatial utilization pattern between the breeding and non-breeding seasons since they are under different intrinsic and environmental constraints. We tracked 16 short-tailed shearwaters (*Puffinus tenuirostris*) breeding in Great Dog Island, Tasmania using geolocators for the complete annual cycle. During the breeding season, all individuals used both south-eastern Australian waters (30-50°S, 145-155°E) around the colony and distant Antarctic waters (55-65°S, 30-160°E). During the 147-day non-breeding season, six birds stayed in the western North Pacific (southern Okhotsk Sea, northern Japan), eight stayed in the eastern North Pacific (eastern Aleutian, Bering Sea), and the other two moved between these regions. Core areas (i.e., within the 50% kernel density contour) of individual birds were larger during the breeding than the non-breeding season ( $7 - 42 \times 10^4 \text{ km}^2$  vs.  $6 - 18 \times 10^4 \text{ km}^2$ ), and also showed much greater overlap during breeding, reflecting the central place foraging constraint. Individuals using either of the two distinct areas in the western and eastern North Pacific are likely to face differing environmental and anthropogenic stresses during the non-breeding season.

## PALMYRA ATOLL RESTORATION PROJECT: RAT REMOVAL CREATES REFUGE FOR CENTRAL PACIFIC FLORA AND FAUNA

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Palmyra Atoll National Wildlife Refuge is a moist central Pacific atoll that supports one of the best remaining habitats for the tropical broadleaf tree, *Pisonia grandis*, as well as 10 species of breeding seabirds totaling more than 325,000 individuals, and a robust population of the world's largest terrestrial invertebrate, the coconut crab (*Birgus latro*). Despite these riches, the atoll

ecosystem has been greatly compromised by introduced rats (*Rattus rattus*) that were inadvertently brought to the atoll during WWII. In the presence of rats, several native tree species have experienced limited to no recruitment, and it is likely that rats caused the extirpation of up to eight seabird species. Between June 1 and 30, 2011, a partnership between the US Fish and Wildlife Service, The Nature Conservancy, and Island Conservation successfully implemented a project to remove all rats from Palmyra. Independent monitoring of the bait application and environmental effects from this action was undertaken by the US Department of Agriculture. Initial findings show minimal non-target impacts as a result of the project. Early, post-eradication monitoring demonstrates a significant increase in recruitment by at least two native tree species, including *P. grandis*. By removing rats from Palmyra, the partnership aims to safeguard the atoll's indigenous flora and fauna, encourage the reestablishment of extirpated species of seabirds, and create a refuge for species within the central Pacific region. This project is a monumental conservation milestone for the Refuge and has established a benchmark for eradication campaigns on other tropical islands.

#### ANCIENT DNA REVEALS RESILIENCE DESPITE THE THREAT OF EXTINCTION: THREE THOUSAND YEARS OF POPULATION GENETIC HISTORY IN THE ENDEMIC HAWAIIAN PETREL (*PTERODROMA SANDWICHENSIS*)

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In the Hawaiian Islands human colonization is associated with the extinction or decline of many species. Two populations of the endemic Hawaiian petrel (*Pterodroma sandwichensis*) have likely been extirpated and those remaining have decreased. We obtained mitochondrial DNA sequences from 417 birds up to 3,500 years old to investigate patterns of gene flow and temporal changes in the genetic diversity of this endangered species. Overall, differentiation was high between populations on each island; however, birds from extirpated colonies on Oahu and Molokai were not significantly differentiated from modern birds on Lanai. No significant changes in genetic diversity have occurred despite previous fears that this species was extinct. Modeling demonstrates that the decline was probably not as severe as previously thought, and simulations show that even a severe decline would result in the loss of minor levels of heterozygosity. Simulations also show that high levels of genetic diversity may have been retained due to the long generation time of this species. Therefore, dispersal in addition to long generation time, may have allowed the Hawaiian petrel to escape a genetic bottleneck after the human colonization of the Hawaiian Islands.

#### REVIEW OF PELAGIC FISH DISTRIBUTION AND PROJECTED CHANGES WITH CLIMATE CHANGE

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In the Central Tropical Pacific (CTP), tunas are the major driver behind subsurface predator facilitated foraging, a key foraging mechanism for seabirds. Therefore the management of tuna stocks has implications for seabirds. Yellowfin (*Thunnus albacares*) and skipjack (*Katsuwonus pelamis*) tunas are the key players in tuna-seabird interactions in the CTP because they are found closer to the surface than bigeye, the other key tropical tuna species. Tunas are of particular importance to breeding seabirds as they frequently found within their foraging ranges. We review the oceanographic characteristics of skipjack and yellowfin habitat, and predictions of how the distributions of these species may change under predicted changes in earth's climate. These changes in tuna distribution may shift foraging habitats for subsurface foraging seabirds.

#### SEABIRD ASSOCIATIONS WITH PREY AND HYDROGRAPHIC FEATURES OFF OF THE NORTHWEST ATLANTIC SHELF DURING LATE SUMMER

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A ship-board survey of seabird and zooplankton communities off the northwest Atlantic continental shelf (roughly between latitudes 35°N – 52°N) was conducted during August 2011. The survey transects crossed a variety of hydrographic and topographic features that strongly influenced seabird and zooplankton distribution, abundance, and species richness. Some of the most interesting communities were encountered crossing the New England Seamount chain; transition waters between the Gulf Stream and Labrador Current; and areas of internal wave propagation originating from the Tail of the Bank (Grand Banks, Newfoundland) and the Flemish Cap. A major spike in seabird diversity and abundance, as well as an overall change in community composition, was recorded across an abrupt salinity front and freshwater anomaly as we approached the northern portion of the study area.

#### POPULATION STATUS OF JAPANESE MURRELETS (*SYNTHLIBORAMPHUS WUMIZUSUME*) AT BIROJIMA, JAPAN, IN 2011

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To better assess population size, an international team of researchers conducted surveys of Japanese Murrelets (*Synthliboramphus wumizusume*) at Birojima, Miyazaki Prefecture, Japan, in April 2011. Birojima hosts the largest known Japanese Murrelet colony in the world, but population status has not been examined since the mid 1990s. Survey techniques included: (1) spotlight surveys to count murrelets attending nocturnal at-sea congregations in near shore waters; (2) “night-lighting” captures to determine the breeding status of murrelets attending at-sea congregations; and 3) nest searches and hand/mist-net captures of murrelets on the island to assess timing of breeding. Six spotlight surveys were conducted over four nights along a 2.9 km transect circumnavigating Birojima about 200-300 m from shore. Spotlight survey counts ranged from 207-536 murrelets (352-911 birds km<sup>-2</sup>), with highest counts 1-2 hours after dusk before many murrelets had flown up to the island. Observations of eight family groups departing the island and many hatched eggshells indicated that surveys were conducted late in the breeding season after many adults had left the colony. Only two (13%) of 16 murrelets captured on the water, and 16 (42%) of 38 birds captured on the island had brood patches. Unfortunately, field work was delayed until late April due to the natural disasters which struck Japan in March 2011. We consider that numbers of murrelets counted were consistent with past population estimates up to 3,000 birds. More work is needed during peak breeding to better estimate current population size and develop a long-term monitoring program at Birojima.

#### STABLE ISOTOPES AS INDICATORS OF MODERN AND HISTORICAL FORAGING ECOLOGY IN THE HAWAIIAN PETREL

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Stable isotope analysis can provide insight into otherwise intractable aspects of seabird feeding ecology. Here, we use stable carbon and nitrogen isotope values ( $\delta^{13}\text{C}$  and  $\delta^{15}\text{N}$ ), indicators of foraging location and trophic level, to study colonies of the Hawaiian petrel (*Pterodroma sandwichensis*) through the past 4,000 years. We find significant isotopic segregation among modern breeding colonies from different

islands, consistent with variability in feeding location during the periods of flight feather synthesis. Isotope results from modern and ancient, radiocarbon-dated bone collagen further show that isotopic segregation, at least between colonies on the islands of Maui and Hawaii, has persisted through the past 2,000 years. Temporally, the most pervasive trend we observe is a 1.4 to 2.6 ‰ decline in  $\delta^{15}\text{N}$  for colonies on Maui, Hawaii, and Lanai during the past 1,000 years. This species-wide shift stands in contrast to temporally consistent  $\delta^{13}\text{C}$  values, as well as  $\delta^{15}\text{N}$  values prior to 1,000 years BP. Recently declining  $\delta^{15}\text{N}$  values likely reflect a human-induced change in trophic level, which could have consequences for reproductive success and foraging efficiency. Given the large range and high mobility of the Hawaiian petrel, their shifting foraging habits could reflect widespread alterations in pelagic food webs of the NE Pacific Ocean.

#### ENTANGLEMENT EFFECTS ON MARBLED MURRELETS (*BRACHYRAMPHUS MARMORATUS*) IN SALISH SEA SALMON FISHERIES OF THE PACIFIC NORTHWEST

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Salmon are an icon of the Pacific Northwest in the United States. From the first northwestern immigration of Native Americans to the European settlers moving west in the 16th century, salmon have been a rich ceremonial, subsistence and economic trade source. Challenges for federal, state and tribal entities ascend from incidental bycatch of a remarkably rare seabird found in salmon gillnet fisheries conducted in the Salish Sea. As humans and birds continue to compete for food sources in the marine environment can equilibrium between salmon and marbled murrelets be achieved? In the Salish Sea, offshore drift gillnet and nearshore set gillnet fisheries efforts have increased over the last ten years. The primary foraging strategy of alcids is pursuit-diving. Diving and remaining at deeper depths than surface feeders, murrelets are more vulnerable to entanglement in fishing gear. From 2001-2010, the number of wintering birds in Puget Sound and the Strait of Juan de Fuca has declined by 7.4% per year. Puget Sound demonstrates the highest juvenile to adult ratios in the Pacific Northwest thus; any impacts from net fisheries could vitally affect the decreasing marbled murrelet population. Declines due to gillnet mortality could be expansive but short-term once the source of murrelet mortality is reduced. Gillnet seabird regulations adopted by Washington State include gear modifications, night and morning change of light closures and fishing area closures. This report explores what more can be done to reduce gillnet entanglements to assist in stabilizing marbled murrelet population trends in the State of Washington.

#### MIGRATION OF STREAKED SHEARWATERS: FROM TEMPERATE TO TROPICAL OCEANS

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At-sea distribution and behaviour of migratory seabirds outside breeding season are usually difficult to examine, and sex-related and inter-colony differences as well as individual consistency in migratory behaviour have been less understood for seabirds. Streaked shearwaters (*Calonectris leucomelas*) breed in temperate regions of East and Southeast Asia, and, on the basis of a limited number of ring recoveries, they are thought to migrate to tropical regions after breeding. In this study, we examined the migratory behaviour of streaked shearwaters breeding at three colonies in Japan using Global Location Sensors from 2006 to 2010. We tracked 172 streaked shearwaters, including 47 birds tracked for two successive years, and obtained data of 220 migrations in total. During non-breeding period, streaked shearwaters migrated to four wintering areas in the tropics: seas off northern New Guinea (73.1% of migration), Arafura Sea (17.0%), South China Sea (9.0%), and seas off western Australia (0.9%). Most shearwaters, including males and females, from three colonies migrated to the seas off northern New Guinea, though there were slight sex-related and inter-colony differences in the secondary wintering areas, the Arafura Sea and South China Sea. All individuals (47 birds), except one male, migrated to the same wintering areas over two successive years. The mean distance between the centroids of the wintering areas of the same individual for two successive years was  $386 \pm 326$  km. Our results revealed the key wintering area for the streaked shearwater breeding in Japan, and their high repeatability in migratory behaviour.

#### BREEDING STATUS, AT-SEA DISTRIBUTION AND CONSERVATION OF THE JAPANESE MURRELET ON THE NORTHERN IZU ISLANDS, JAPAN

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The Japanese Murrelet (*Synthliboramphus wumizusume*) is a small seabird of the alcid family. It is listed as Vulnerable to Extinction by the IUCN Red List with approximately 5000 birds worldwide. It breeds on rocky islets, and its distribution is restricted to the warm-current region of the central and southern part of Japan and the southern part of South Korea. We conducted a boat survey in April and May of 2009-2011 around the northern Izu Islands, including isles of Inanba and Zenisu where no surveys have previously been undertaken. Murrelets were mainly observed around Han-shima, Tadanae-jima, Onbase-jima and Onohara-jima Islets with an average of 408 (range 321- 547) birds during five surveys. We also found evidence to support their breeding at six sites. During the post-breeding period (June-September), no murrelets were recorded in the northern Izu Islands but were observed along the Pacific coast of Honshu and off eastern Hokkaido, suggesting that they migrate north. These results have conservation implications, providing baseline information about important habitats of the Japanese Murrelet around the northern Izu Islands that could become candidate marine Important Bird Areas (marine IBAs) for the species.



## GLOBAL POPs MONITORING USING SEABIRDS PREEN GLAND OIL.

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As marine top predators, seabirds accumulated persistent organic pollutants (POPs), such as polychlorinated biphenyls (PCBs), dichlorodiphenyltrichloroethane and its metabolites (DDTs) and hexachlorocyclohexanes (HCHs), in their tissues through biomagnification. In a previous study, we demonstrated the usefulness of preen gland oil of seabirds as a nondestructive biomonitoring tool. In this study, we analyzed PCBs, DDTs and HCHs in preen gland oil from 97 live individuals including 83 adults (17 species) and 15 chicks (5 species) from eight locations over the world oceans during 2005-2009. PCBs, DDTs and HCHs concentrations of seabirds preen gland oil were higher in the northern hemisphere than the southern hemisphere. Especially, PCBs were highly concentrated in European shags (*Phalacrocorax aristotelis* in U.K.) and DDTs and HCHs were concentrated in black-tailed gulls (*Larus crassirostris* in Japan). These results suggest that their foraging areas might be close to pollutant sources. PCB and DDT concentrations in preen gland oil from adult black-tailed gulls were 2-3 orders of magnitude higher than chicks, while HCH concentrations from the adults and the chicks were similar. In the chicks, lower chlorinated congeners (more metabolizable congeners) were more abundant than adults, suggesting that chicks' metabolic system has not been established. The nondestructive biomonitoring of POPs in seabird's preen gland oil can be carried out simultaneously with ecological investigations, therefore provides us helpful information to understand the global distribution and transport of POPs and their effects on seabirds.

## THE ROLE OF TROPHIC NICHES IN DEFINING SEABIRD-FISH INTERACTIONS IN THE PACIFIC OCEAN

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The low productivity and unpredictable nature of resources in tropical waters would appear to make resource partitioning among predators difficult. Yet, stable isotope data from multiple studies in tropical environments suggest that substantial resource partitioning occurs among tropical seabird communities, both between seabirds and among various seabird and other pelagic predators that forage jointly (i.e. tuna). In this study, we compare  $\delta^{13}\text{C}$  and  $\delta^{15}\text{N}$  levels among various sympatric tropical seabird species and other marine predators. For a subset of the seabird species, we also examined isotopic levels across years, breeding periods, and sexes. As a group, seabirds were isotopically distinct from other marine predators, viz. pelagic fishes and squid. However, there are numerous methodological challenges in drawing trophic conclusions based on isotopic variation among tissue from these taxa that make it difficult to interpret these results without further corroboration from stomach contents, direct tracking, and/or compound specific isotopic analyses; while some of this supplementary work has been conducted, much more is needed.

#### A STORY OF PREDATION, ERADICATION AND RECOVERY AT ONE OF OAHU'S LARGEST SEABIRD COLONIES: KAENA POINT NATURAL AREA RESERVE

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The 20 ha coastal strand ecosystem of Ka'ena Point Natural Area Reserve on Oahu, Hawaii hosts one of the largest seabird colonies in the main Hawaiian Islands and contains 11 species of endangered plants. Due to the negative impacts of invasive mammals on native species, construction of a predator-proof fence was proposed in 2006 and completed in early 2011. Predator removal efforts began upon fence completion and were informed by two years of rat and mouse monitoring. Diphacinone in bait boxes spaced 25m apart and multiple catch mouse traps spaced 12.5 apart were deployed to remove rodents (*Rattus rattus* and *Mus musculus*) and small Indian mongooses (*Herpestes javanicus*). Cats were removed with a combination of cage traps and padded leghold traps. Tracking tunnels were run monthly and spatial maps of rodent catch were generated to determine areas of high mouse activity. Snap traps were deployed in areas of high activity, and bait was switched or refreshed in surrounding live traps in these areas. Cats, rats, and mongooses were eradicated within three months, and mice were likely eradicated after eight months pending verification, though a few incursions have occurred since. The removal of predators has already resulted in a record number of Wedge-tailed Shearwater (*Puffinus pacificus*) chicks in 2011, and is expected to result in increased Laysan Albatross (*Phoebastria immutabilis*) reproduction in 2012. Predator exclusion and removal is also anticipated to encourage other seabird species to nest at Ka'ena Point, and to enhance regeneration and recruitment of native plants and invertebrates.

#### LINKING METABOLIC STRESSORS TO SENESCENCE IN LONG-LIVED SEABIRDS

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Senescence may be caused by accumulated cellular damage, especially that caused by oxidative stress. Oxidative stress is caused by metabolic stressors, such as growth or reproduction, and is mitigated by antioxidants and cellular mechanisms. Such mitigations may be overcome or halted by disease processes or energetically expensive behaviors like reproduction. Examination of telomeres, DNA fragments especially vulnerable to oxidative stress and linked to aging and survival rates, is a new relatively non-invasive technique that may be used to monitor senescence, and in some species is precise enough to use as an aging tool. We tested the relationship between metabolic stressors (number of reproductive events) and immune challenges (disease) in two closely-related long-lived seabirds, the horned puffin (*Fratercula arctica*) and the parakeet auklet (*Aethia psittacula*). We also tested the utility of telomere attrition as an aging tool. We measured telomeres of captive individuals of known age who also have complete reproductive and disease histories. This unique dataset allows evaluation of the effects of common diseases and multiple reproductive attempts in a semi-controlled environment (e.g. lack of predators, control of reproductive attempts, veterinary care provided). This study helps uncover long-term costs of disease and reproduction that may affect lifespan and future reproductive efforts in free-living seabirds.

#### EASTERN BERING SEA COMBINED SEABIRD INDICES SHOW LAGGED EFFECTS OF BOTTOM TEMPERATURES AND FOOD SUPPLY ON REPRODUCTION

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There is great need to develop ecological indicators that can inform ecosystem managers and policy-makers of the ecological state of the marine environment. Indicators should be both useful to managers as well as have a sound scientific base (Frederiksen et al. 2007). The goal of this study was to integrate existing data into a simplified measure seabird trends in the eastern Bering Sea. This index could then provide a quick assessment of status and trends and enable hypothesis-testing of the effects of fishing and environmental factors on top predators. We used principal components analysis to integrate existing reproductive effort data from common murres *Uria aalge*, thick-billed murre *U. lomvia*, black-legged kittiwake *Rissa tridactyla*, red-legged kittiwake *R. brevirostris*, and red-faced cormorants *Phalacrocorax urile*. Two strong and distinct patterns were evident in the first two principal components (PC). PC1 represented seabird phenology and murre productivity; PC2 represented kittiwake productivity. Time series analysis of these indices against select environmental variables showed significant but lagged relationships. Strong negative correlations at 1 and 2 years lags between PC1 and mean bottom temperature indicated that the warmer in year  $x$ , the later and less productive seabirds were in year  $x+1$  and  $x+2$ . A strongly significant 1 year lag between local age-1 walleye pollock *Theragra chalcogramma* abundance with PC2 indicated that more age-1 pollock, a forage fish, the higher kittiwake productivity was the following year.

## IMPACTS OF RENEWABLE OCEAN ENERGY DEVELOPMENT ON SEABIRDS IN THE CALIFORNIA CURRENT ECOSYSTEM

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Development of clean, renewable ocean energy sources is a high priority due to growing energy demand in coastal regions of the USA. Coastal waters in California, Oregon, and Washington support millions of seabirds as well as providing a migratory corridor for non-resident seabirds, shorebirds, and waterfowl. Significant initiatives are in place to develop and deploy energy devices that convert tidal, wave, or wind energy into electricity. Very little is known about direct or indirect effects of such devices on birds at sea, or on the marine food web supporting birds. Data on bird distribution, abundance, behavior, and habitat use are clearly needed to inform the device design process, select sites for deployment, evaluate before/after comparisons at individual sites, and determine cumulative impacts across device arrays and multiple sites. In theory, marine spatial planning processes should provide a mechanism where science directly advises decision-making. However, permits and zoning for energy development are moving ahead rapidly on multiple fronts, making it challenging to ensure seabird information keeps pace with both planning and research needs in this new arena.

Oral and poster presentations in this Special Session highlight the need for seabird biologists to understand and actively participate in advising the ocean energy development process. Emerging work includes development of synthetic, contemporary, coast-wide data sets; placing bird distributions in an ecosystem context which considers ocean habitat features and prey availability; technological innovation to address data gaps; and adapting and applying lessons learned in Europe, among other efforts.

## PANEL DISCUSSION AND FEEDBACK PERIOD – UNIFYING THEMES, DATA GAPS, AND RESEARCH PRIORITIES RELEVANT TO SEABIRDS AND OCEAN ENERGY DEVELOPMENT

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This forty-five minute session will begin with an introduction of panelists (David Pereksta, Bureau of Ocean Energy Management; Robin Hartmann, Oregon Wave Energy Trust) and an explanation of their roles at the interface of seabird conservation and ocean energy development. There will then be an opportunity for the audience to ask questions of or provide comments to the panelists or other session participants. Finally, the facilitator will solicit input from all session participants. Based what was presented during oral and poster presentations as well as the panel discussion, participants will be asked to identify the following: (1) important unifying concepts or themes which emerged from the session; (2) unaddressed issues or data gaps; and (3) near-term actions or research priorities. The facilitator will provide a simple one-page form to those who wish to record feedback. A short written summary of feedback received, as well as any recommendations or action items coming out of the session, will be provided to 2012 Science Chair by the facilitator. With approval of the Science Chair, the written summary will be communicated to all PSG members in *Pacific Seabirds*.

