

RELATIVE CONTRIBUTION OF EUPHAUSIID PREY SPECIES AND TIMING OF BREEDING TO AUKLET GROWTH: WITHIN-SEASON EFFECTS

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Within-season variation in life-history parameters is characteristic of long-lived seabirds breeding in dynamic marine environments. Zooplanktivorous Cassin's Auklets (*Ptychorhamphus aleuticus*) breeding in central California feed primarily on euphausiid crustaceans, and switch from provisioning their offspring primarily with *Euphausia pacifica* early in the nestling period to *Thysanoessa spinifera* later in the nestling period. We examined the effects of seasonal variation in auklet parental provisioning (relative diet composition and provisioning mass), and timing of breeding and breeding attempt number (first/only or second breeding attempt) on the growth rate of individual nestlings on Southeast Farallon Island, California. For individual years, there were variable seasonal trends in growth, but no trends were apparent when all years were combined. Overall, there was a seasonal shift in prey use from *E. pacifica* early to *T. spinifera* later in the breeding season and a concurrent decrease in provisioning mass. In multivariate models, there were significant and positive effects of *E. pacifica*, *T. spinifera*, provisioning mass and breeding attempt number on nestling growth, while the effect of hatching date on growth was negative. The relative influence of *T. spinifera* on growth was stronger than that of *E. pacifica*, the effects of hatching date on growth were likely dependent on the effects of breeding attempt, and breeding attempt exerted the strongest effect on nestling growth of all parameters examined. Results provide compelling evidence that relative diet composition, provisioning amount and breeding attempt have positive effects on auklet growth, suggesting that the seasonal switch in prey use is adaptive, and thereby illustrating the importance of adequate availability of both *E. pacifica* and *T. spinifera* to auklets in the Gulf of the Farallones. This study represents a unique approach in the investigation of linkages between individual nestling growth rate and diet and breeding phenology parameters by focusing on a fine temporal scale.

SUMMER MOVEMENTS OF 'UA'U (HAWAIIAN PETREL *PTERODROMA SANDWICHENSIS*) NESTING ON HALEAKALĀ, MAUI AND LĀNA'I: CAN WE USE SATELLITE TRACKING TO GAIN NEW INFORMATION AND ADVISE CONSERVATION MANAGEMENT?

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Predation and habitat degradation by non-native species are principal threats to endangered Hawaiian Petrel ('Ua'u, *Pterodroma sandwichensis*) and threatened Newell's shearwater (*Puffinus auricularis newelli*). High priority recovery actions for these seabirds include predator control, habitat restoration, and population monitoring. *Required prerequisites for conservation actions include* (1) obtaining precise locations of remote, montane nesting areas, (2) refining techniques for population assessment, and (3) identifying at-sea habitat. We report on our ability to use satellite telemetry to track the movements of medium-sized (~400-g) 'Ua'u to help meet these prerequisites for conservation. In summer 2006, we tracked the fine-scale movements of four 'Ua'u: two individuals from separate nest sites provisioning chicks on Lana'i and one parent provisioning a chick and one failed breeder from nest sites on Haleakalā, Maui. Two transmitters were removed after parents completed long (approximately three weeks), clockwise looping foraging trips throughout a broad area of the north Pacific (individual trips can exceed 10,000 km). We discuss the foraging movements of individual 'Ua'u in the context of their pelagic habitat and relate these to what little is known about the species' at-sea distribution. Tests on Haleakalā, indicate the feasibility of using satellite telemetry techniques in the near future to track the inland movements of both petrels and shearwaters to locate previously undescribed colony locations—an action required for effective management and conservation.

Successful use of this technology to track deep diving Newell's Shearwaters will require modification of existing satellite tag design.

TRENDS IN NUMBERS AND DISTRIBUTION OF BREEDING GLAUCOUS-WINGED GULLS (*LARUS GLAUCESCENS*) AND HYBRID GULLS (*L. GLAUCESCENS* X *L. OCCIDENTALIS*) IN THE COLUMBIA RIVER ESTUARY AND PUGET SOUND AREA

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Numbers of some colonial waterbird species breeding in the Columbia River estuary have increased dramatically during the last two decades (e.g., Caspian Terns [*Hydroprogne caspia*] and Double-crested Cormorants [*Phalacrocorax auritus*]). Numbers of breeding Glaucous-winged/Western Gulls in the estuary also have increased substantially, but now appear to be in decline. The Catalog of Washington Seabird Colonies lists 1,750 breeding gulls on East Sand Island in 1982. Counts from aerial photography of nesting hybrid gulls at the same site during the period 1996-2000 ranged from 5,496 to 9,523 individuals. In 2001 this number increased to 12,066 and in 2006, the year of the next aerial count, only 8,587 nesting hybrid gulls were counted. Additionally, we examined numbers and distribution of Glaucous-winged Gull colonies in the greater Puget Sound area to determine the extent of use of anthropogenic colony sites, such as warehouse rooftops, as the use of this habitat by gulls has increased while colonies in natural habitats (e.g., Protection Island NWR) have reportedly been in decline. A total of 9,882 breeding gulls and 3,640 gull nests were counted from aerial photographs taken in June 2006. This is down from the 14,194 breeding gulls listed for a similar area around 1982 in the Washington Seabird Colony Catalog. Although it appears that breeding gulls on dredge spoil islands and urban rooftops in the Puget Sound area has increased by nearly 90% since the early 1980's, the ca. 60% decline on Protection Island NWR is greater than increases observed at these anthropogenic sites.

POINT/COUNTER-POINT? SOME MYTHS AND POINTS SURROUNDING A RE-LISTING PROPOSAL FOR THE CALIFORNIA BROWN PELICAN

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It is unclear if there is a distinct point, counter-point argument here. In 1986, PSG proposed a status change for the California brown pelican (*Pelecanus occidentalis californicus*)(CABRPE). After review, there was hesitancy to act further due to the tentative conservation status in larger populations of the Gulf of California (GC). The CABRPE also acted as a "flagship" species for other seabirds in California. Since, Mexican agencies and NGOs have made significant progress in seabird conservation in the GC. In 2006, the USFWS initiated a new 2006 status review and will soon consider all options for a change in status under the ESA. In essence, there is almost no disagreement from agency and private pelican researchers regarding a change in status (as synthesized by ESRC and supported by PSG), the ultimate decision on specific recommendations should, however be the responsibility of appropriate state and federal agencies, after a thorough review and evaluation of the peer-reviewed scientific data. That ESA special status for the California brown pelican has "undermined" efforts to conserve and manage other species is largely a myth. That recovery of the California brown pelican has been successful is not a myth. Other "myths" and "facts" surrounding the changing conservation status of the CABRPE will be discussed. In contemporary thinking, J. M. Scott et al. (2005) have proposed that conservation efforts after ESA de-listing (and including other sensitive species) treat such entities as "conservation-reliant", still protected, monitored, and managed intensively through various old plus new mechanisms beyond the ESA. I urge PSG to support such progressive conservation.

VARIABILITY IN THE PACIFIC DECADAL OSCILLATION INDEX AND DEMOGRAPHY OF A TROPICAL BOOBY

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The cyclic Pacific Decadal Oscillation (PDO) has apparent effects on the biology of a number of high latitude organisms, but little evidence exists of similar effects at lower latitudes. We examine a long-term demographic dataset from a pelagic seabird, the Nazca booby (*Sula granti*), breeding within 150 km of the Equator, for evidence of sensitivity to oceanic variability associated with the PDO. Coincident with a switch in PDO phase from positive to negative in 1998, the diet of Nazca boobies changed from primarily sardines to primarily flying fish. Also coincident with the phase change, breeding success dropped, as did nestling survival, but annual adult survival showed little correlation with PDO phase. These results suggest that PDO-related oceanographic phenomena represent a significant influence on the reproduction of this tropical species.

MARBLED MURRELET NESTING HABITAT IN ALASKA: A REVIEW OF NEW AND EXISTING INFORMATION.

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Loss of nesting habitat has contributed to the decline of Marbled Murrelets (*Brachyramphus marmoratus*) in other parts of their range, however, little is known about the distribution, amount, and loss of suitable nesting habitat in Alaska. We conducted a review of terrestrial habitat use and availability within the core areas of Marbled Murrelet distribution in Alaska, including Southeast Alaska, Prince William Sound and the Kodiak Archipelago. We used landcover and forest inventory data to examine the distribution of old-growth forest among areas, and we used published and unpublished habitat suitability index models to estimate the amount of potential nesting habitat. Southeast Alaska contains approximately 2.1 million ha of old-growth forest and less than 5% of this is potentially suitable for tree nesting murrelets. Logging has contributed to the loss of 318,000 ha, and habitat suitability has degraded by about 15% since 1986. Prince William Sound contains an estimated 140,000 ha of primarily old-growth hemlock and hemlock-spruce forest, about 133,000 ha have high potential for nesting habitat suitability and less than 1 % of forest service land has been logged. Afognak and Shuyak Islands contain about 93,000 ha of primarily old-growth hemlock-spruce forests and another 17,000 ha have been logged. Although timber harvest has declined in all three core areas of distribution, forest management practices may affect the amount and distribution of nesting habitat in the future, especially in southeast Alaska.

AMERICAN BIRD CONSERVANCY'S SEABIRD PROGRAM: CONSERVING SEABIRDS THROUGHOUT THE AMERICAS

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Seabirds are critical to the marine environment both ecologically and aesthetically. The persistence of many seabird species, however, is threatened by human activities. For example, of the 21 albatross species worldwide, 19 are listed under IUCN as threatened with extinction. Major factors affecting seabird populations include mortality of birds in longline fisheries, invasive animals and plants at breeding sites, contaminants, and ingestion of marine debris. American Bird Conservancy (ABC) is a US-based conservation organization devoted to conserving wild birds and their habitats in the Western

Hemisphere. ABC's Seabird Program focuses on eliminating the greatest threats to seabird populations by working with government agencies, NGOs, and researchers in the areas of conservation, education, and advocacy. Specifically, we strive to eliminate bycatch in the Hawaiian longline fisheries by promoting side setting and complementary techniques to reduce the availability of baited hooks to birds. ABC has pushed to include language on seabird bycatch in the Magnuson Stevens Fishery Conservation and Management Act reauthorization, including language allowing the Act to be used as a potential funding source. We have been actively involved in developing solutions to eliminate the exposure of Laysan Albatross (*Phoebastria immutabilis*) chicks to lead paint at Midway Atoll and support the elimination of golden crown-beard (*Verbesina encelioides*), an invasive plant severely impacting breeding success of seabirds there. Globally, ABC is supporting the development of the National Plan of Action to Reduce Seabird Bycatch in Argentina and working with governments to develop strong regulations promoting seabird-friendly fishing.

LEAD POISONING OF LAYSAN ALBATROSS AT MIDWAY NATIONAL WILDLIFE REFUGE: ASSESSING THE PROBLEM AND DEVELOPING SOLUTIONS

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Midway Atoll, located approximately 1,800 km northwest of Honolulu, consists of 3 islands (Sand, Eastern, and Spit) totaling approximately 1,500 acres and supports the world's largest breeding population of Laysan Albatross (*Phoebastria immutabilis*, 487,527 breeding pairs in 2006). Currently a National Wildlife Refuge and significant part of the newly designated Northwest Hawaiian Island National Marine Monument, Midway was controlled by the US Navy from 1903 until 1988. On Sand Island, lead-based paint chipping from deteriorating buildings constructed during and prior to World War II has resulted in contamination of soils with the highest concentrations of lead-chips immediately surrounding buildings. Research on Sand Island documents that Laysan Albatross chicks raised in close proximity to these buildings ingest this paint and develop a lethal condition of peripheral neuropathy referred to as "droopwing". The latest estimates suggest that lead-based paint may kill as many as 10,000 Laysan chicks per year. Early efforts to reduce lead-based paint exposure with fencing or tarps have been relatively unsuccessful and current efforts are underway to procure funding to complete removal of lead-based paint from Sand Island. This talk will detail the latest research regarding the impacts of lead-based paint on Laysan Albatross and efforts towards a solution.

STORM PETRELS IN THE HUMBOLDT CURRENT SYSTEM: BREEDING AREAS AND CONSERVATION PERSPECTIVE IN PERU.

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We examined the status of storm petrel breeding sites along the coast of Peru and Chile. We gathered published and unpublished information on distribution and size of breeding localities from 1913 to 2006. We found information on breeding localities for White-vented Storm-petrel (*Oceanites gracilis*) in Chile, Markham's storm-petrel (*Oceanodroma markhami*) in Peru, and Wedged-rumped storm-petrel (*Oceanodroma tethys kelsalli*) in both Peru and Chile. In Peru, Markham's storm-petrels breed in at least two islands and one headland all of which are legally protected within the Paracas National Reserve. The Wedged-rumped storm-petrel breeds in four islands, all of them managed by the guano administration. Legal protection has no effect on the conservation of the birds if there are no resources to enforce the law. The Paracas National Reserve, although protected, lacks the resources to protect colonies from human disturbance. The guano administration on the other side has been relatively effective in enforcing rules that eliminates human disturbance to the populations of birds that inhabit islands where guano is produced. However, the collection of guano has brought other problems like the introduction of alien predators which may threaten some of these populations. The introduction of

predators, human disturbance (ship traffic and use of bright lights around the islands) and human competition (industrial fishery for anchovy) are just a few of the threats faced by storm-petrels nesting off the coast of Peru and Chile. The Markham's storm-petrel has been listed by the Peruvian government as an endangered species. The law currently does not protect the Wedged-rumped storm-petrel despite its scarcity.

THE EFFECT OF CLIMATE FLUCTUATIONS ON THE CHICK DIETS AND FORAGING TRIP DURATIONS OF AN ARCTIC SEABIRD, THE LITTLE AUK (*ALLE ALLE*)

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Planktivorous seabirds are sensitive indicators of changes in the ocean because zooplankton often varies with oceanographic conditions. Climate fluctuations affect zooplankton abundance by influencing the distribution of oceanographic currents in which specific zooplankton reside. The little auk (*Alle alle*) is an abundant Arctic seabird that depends on energy-rich zooplankton adjacent to their colonies. Oceanographic currents derived from warmer Atlantic and cooler Arctic water masses support different zooplankton species and vary in energetic content of zooplankton available to foraging little auks. The Arctic derived Sorkapp current brings (*Calanus glacialis*), a large, energy-rich prey species close to the little auks colonies on Spitsbergen, Norway. Atlantic derived water brings the smaller (*Calanus finmarchicus*). This study investigated the effects of climate-induced changes in the distribution of Atlantic and Arctic derived water masses off the southwestern coast of Svalbard on the chick diets and foraging effort of little auks breeding in Hornsund Fjord. The distribution of these currents is linked to interannual atmospheric fluctuations in the North Atlantic Oscillation (NAO). We compared chick diets and foraging trip length from six seasons and determined if they varied with the NAO index. We hypothesized that in years with more Atlantic water, adults would take longer to find food due to the abundance of energetically inferior prey within their foraging range. These relationships are key to understanding how climate change, on interannual and longer-term scales, will affect a key Arctic predator, the little auk. Furthermore, we evaluate the efficacy of measuring foraging trip lengths to indicate prey availability.

SURVEYING SEABIRDS AT SEA IN OCEANIC ECOSYSTEMS - THE NOAA PERSPECTIVE: WHY, HOW, APPLICATIONS, AND AN OPPORTUNITY FOR INTERAGENCY COLLABORATIONS

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The Southwest Fisheries Science Center of NOAA Fisheries regularly conducts marine mammal surveys in large, oceanic ecosystems. An ecosystem-based approach is used on these surveys and seabirds have regularly been included in the suite of ecosystem measures studied since 1986. We use 300-m strip transect methods and record individual birds in real time on a PC using a software program written and maintained in-house. Data on seabird age, sex, association, and behavior are recorded, as well as flight direction, so as to allow for correction if absolute abundance estimates are to be made. In the tropics, a separate strip transect survey is conducted for seabird flocks using identical methods with a strip width of 8 nautical miles, which addresses the problem of ship avoidance by feeding flocks. The primary justification for collecting seabird data is to use them as indicators of ecosystem state. Therefore, trends in distribution and abundance are a primary analytical product. However, basic distribution patterns, absolute abundance, foraging ecology and community patterns can be obtained

from at-sea studies and, while not a primary concern related to NOAA Fisheries mandates, this information is critical to effective management of seabirds. We suggest that the asset of NOAA Fisheries (regular at-sea surveys using an ecosystem-based approach to management) and the primary management responsibility for seabirds of other agencies, often with limited abilities to conduct research at sea, form the basis for a productive collaboration. Formalizing the at-sea study of seabirds between agencies could benefit the science and conservation of seabirds.

INCONSISTENCIES BETWEEN AT-SEA AND BURROW CENSUSES OF PACIFIC GADFLY PETREL POPULATIONS.

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**Deceased

Total population estimates for four species of *Pterodroma* made in the eastern Pacific 1980-1995 are compared with estimates from the breeding colonies. For Hawaiian Petrels (*P. phaeopygia*) the results are very close, well within the 95% confidence intervals for the at-sea estimate. However, for Cook's Petrel (*P. cookii*), De Filippi's Petrel (*P. defilippiana*), and White-winged Petrels (*P. leucoptera*) the at-sea estimates are very different. Reasons for these discrepancies are proposed and evaluated. We found that the most serious potential sources of error for at-sea censuses are: misidentification of species; attraction of birds to the survey vessel; incomplete coverage of the species' at-sea range; and failure to adjust the boundaries of the at-sea range to reflect rapid and extensive seasonal changes in distribution. Most of these errors lead to over-estimation of abundance. Improved design of cruise tracks and continued refinement of counting techniques can reduce these errors. The principal errors for shore-based estimates are: failure to detect all breeding populations; under-counting of burrows in difficult terrain; and difficulties in estimating the proportion of non-breeders. These errors all lead to underestimation of the population size. Predictive habitat modelling of burrow abundance can greatly reduce such errors, without a corresponding increase in sampling effort. However, we conclude that, despite a tendency to overestimate abundance, at-sea censuses provide an invaluable check on whether shore-based burrow counts are complete. They also provide additional data on population trends and on changes in foraging patterns which reflect fundamental shifts in marine ecosystems.

PHYSIOLOGICAL STATE OF INCUBATING KING EIDERS

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Female waterfowl rely to a varying degree on stored reserves to meet their maintenance needs during incubation. King Eiders (*Somateria spectabilis*) are near the extremes of the waterfowl continuum in severity of climate and incubation constancy. However, it is unknown if, or to what degree, King Eider females rely on exogenous resources during incubation. We measured plasma concentrations of variables associated with lipid metabolism (free fatty acid, glycerol, triglyceride, and β -hydroxybutyrate), protein metabolism (uric acid), and corticosterone to evaluate the nutritional and physiological state of incubating King Eiders at two sites on the coastal plain of northern Alaska, Kugaruk and Teshekpuk. Baseline corticosterone and triglyceride increased during incubation ($F > 4.8$, $P < 0.05$) while glycerol, β -hydroxybutyrate, free fatty acid, and uric acid did not ($F < 0.8$, $P > 0.05$). Triglyceride and β -hydroxybutyrate were higher at Kugaruk ($F > 6.8$, $P < 0.02$) while glycerol was higher at Teshekpuk ($F = 5.45$, $P = 0.03$), there were no other site differences ($F < 1.0$, $P > 0.05$). It appears that King Eiders were feeding during incubation and that feeding increased as incubation

progressed concomitant with an increase in corticosterone. Fat reserves were not completely depleted and there was no change in protein catabolism during incubation. Site effects were contradictory; incubating females at Kuparuk fed more but had higher lipid mobilization. This may be reflective of short-term feeding bouts in addition to longer-term fasting over the course of incubation and could be reflective of site quality or ambient temperature differences.

MARBLED MURRELET POPULATION ESTIMATION AND TREND MONITORING IN BC

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We revisit the most recent (2002) population estimate of 55,000-78,000 (median 66,000 birds) Marbled Murrelets in British Columbia. In 2002 most of the vast coastline of British Columbia did not have count data and estimates were based on several methods of extrapolating from at-sea or radar counts covering portions of each of the six conservation regions established by the Canadian Marbled Murrelet Recovery Team. Since 2002 the development of program to monitor population trends has lead to many additional new and replicated radar surveys in Haida Gwaii (2004, 2005), North Coast (2003, 2005), Central Coast (2006), South Coast (2006), East Coast Vancouver Island (2003, 2004, 2005, 2006) and sections of the West Coast Vancouver Island (2003, 2004, 2005, 2006) Marbled Murrelet Conservation Region. The total population estimate is larger than previously reported because more sites have been surveyed, radar gear has been modified in some instances to detect more birds (tilted upward), and in part because the initial surveys of the Central Coast region were conducted during the 1998 El Nino summer, one of the poorest years on record for attendance and breeding success on Triangle Island, near the Central Coast region. Counts of Marbled Murrelet in 2006 were on average 2.5 times higher than in 1998 at 10 radar stations in the Central Coast region, consistent with large scale oceanographic impacts on breeding in seabirds. The recent radar data and updated information on marine distribution and abundances was being assembled and integrated the time of writing.

GLOBAL POPULATION GENETIC STRUCTURE AND CONSERVATION OF MARBLED MURRELETS.

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Information about the distribution of genetic variation within and among local populations of marbled murrelets is needed to aid their conservation. We compared variation in the mitochondrial control region, nine nuclear introns and 15 microsatellite loci among 282 marbled murrelets from throughout their range. No strong evidence for either inbreeding or low genetic variation was found within any site. Several analyses indicated that population genetic structure exists: (1) global estimates of F_{ST} and its analogs were statistically significant; (2) estimates of F_{ST} for pairwise comparisons of populations involving the western or central Aleutian Islands and/or central California were significant; (3) Mantel's tests indicated a correlation between genetic and geographic distance; (4) molecular assignments indicated three genetic populations; and (5) nested clade analysis of mitochondrial DNA sequences revealed weak phylogeographic structure. These approaches consistently identified peripheral populations, i.e. those in the western and central Aleutian islands and central California, as differentiated from populations in the central portions of the range. Populations between northern

California and the eastern Aleutian islands do not appear to be differentiated. We suggest that marbled murrelets include three genetic units: (1) western and central Aleutian islands, (2) eastern Aleutian islands to northern California, and (3) central California. Gene flow occurs among these units but is very low. Populations in central California and the western Aleutians are in special need of protection given their peripheral location and genetic divergence.

TROPHIC RELATIONSHIPS AMONG SEABIRDS AND SEAHORSES

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Seahorses (*Hippocampus* spp.) are a taxon of conservation concern and have recently been listed in Appendix 2 of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). Despite evidence of decreases in a number of populations of seahorses and related pipefishes (collectively, Syngnathidae), there is little published information on the causes responsible for these decreases, especially where natural factors (e.g. productivity and predation) may be responsible. However, pipefish (*Syngnathus* spp.) have recently been recorded in high numbers in the diets of seabird chicks around the North Sea and Iceland, and there is evidence that marine birds prey on seahorses and pipefishes in other coastal ecosystems at localities as disparate as Australia and England. As part of my doctoral thesis, I will be investigating the role of vertebrate predators in the population dynamics of syngnathids. Here I (a) present information on recent, anomalous instances of intensive seabird predation on syngnathids, (b) suggest two preliminary hypotheses for this prey switching, and (c) solicit information from seabird researchers on other instances of the occurrence of seahorses or pipefishes in the diets of marine birds.

SEX DIFFERENCES IN SPACE USE OF FORSTER'S TERNS IN SOUTH SAN FRANCISCO BAY, CALIFORNIA

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In seabirds, sex-specific parental care roles during incubation and chick rearing can lead to sexual differences in foraging location, behavior, and use of foraging areas. Most research has focused on dimorphic species, attributing sex differences in foraging to size-based mechanisms. However, for a few species, sex-specific differences in location and use of foraging areas among sexually monomorphic seabird species have been documented. In 2005 and 2006, we captured and radio-marked pre-breeding Forster's terns (*Sterna forsteri*), a monomorphic and monogamous seabird, within Don Edwards San Francisco Bay National Wildlife Refuge in the South San Francisco Bay, California to examine sex differences in space use. Forster's terns were tracked aerially and using truck-mounted telemetry systems throughout the San Francisco Bay region. For both sexes, we estimated foraging home-range and core-area size, and average and maximum distance traveled from colony to foraging sites. In 2005, male Forster's terns averaged significantly larger home-range and core-area sizes and traveled farther to foraging sites than female terns. Sex-specific differences in space use by Forster's terns may be due to differences in energy requirements, foraging efficiency, or parental care roles between the sexes. Understanding sex differences in space use of Forster's terns is imperative to understanding sex differences in contaminant uptake in the species and may aid in habitat conservation within the South San Francisco Bay.

COLONY FORAGING AREAS AND SPACE USE OF FORSTER'S TERNS IN THE SOUTH SAN FRANCISCO BAY, CALIFORNIA

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In the San Francisco Bay, California, Forster's terns (*Sterna forsteri*) nest primarily on island or levee habitats provided by artificial salt evaporation ponds. In 2005, we captured and radio-marked 31 pre-breeding Forster's terns at colony sites within Don Edwards San Francisco Bay National Wildlife Refuge (DESFBNWR) to determine colony and individual foraging areas and examine colony differences in space use. Forster's Terns were tracked aerially and using truck-mounted telemetry systems throughout the San Francisco Bay region. We estimated foraging home-range and core-area size and distance traveled from colony to foraging sites. Forster's terns average (\pm SE) a home-range size of 3,745 (\pm 614) ha and a core-area size of 732 (\pm 99) ha. We found no difference in home-range size, core-area size, or distance traveled between individuals captured at different colonies. Foraging core-areas of all individual terns and colonies encompassed artificial salt evaporation ponds within DESFBNWR, indicating the importance of salt pond habitat for foraging terns. Forster's terns are potentially faced with vast habitat alterations as restoration efforts in the South San Francisco Bay aim to convert artificial salt pond habitat to tidal marsh. To effectively manage this species, colony site conservation will need to be coupled with conservation of near-colony salt pond habitat.

ARE ALL PLOTS CREATED EQUAL? : LONG TERM INTRA-COLONY VARIATION IN WESTERN GULL BREEDING SUCCESS

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While we know that demographic traits for a particular seabird species vary spatially within a colony in a given year, how stable is this spatial variation in breeding parameters over a multi-decadal time scale? We explored this question by examining long term variation in breeding success in the 3 distinct plots of known age Western Gulls (*Larus occidentalis*) - C, H, and K plot - on Southeast Farallon Island, California from 1983-2006. Our models controlled for year and age and utilized data from over 3500 breeding attempts. There were no differences in clutch size between plots. Hatching success was consistently higher for one plot (C) while the other two plots were relatively similar. Stronger results were observed with productivity and fledging success, where a stable "hierarchy" of productivity between the plots (C>H>K) was maintained for ~15 years from 1991-2005. We found significant interactions between year and plot in all analyses. These long term trends and cycles in productivity between plots, after controlling for age and year effects, suggest potential differences in quality of breeding habitats and individuals between plots. We dedicate this paper to the memory of Larry Spear, who helped initiate the long term studies of Western Gulls on the Farallones.

MULTILEVEL MODELS REVEAL NO COHORT-LEVEL VARIATION IN TIME SPENT FORAGING TO EXPLAIN A COLLAPSE IN KITTIWAKE (*RISSA TRIDACTYLA*) BREEDING SUCCESS.

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As central-place foragers, colonial seabirds should be able to compensate, up to some threshold, for changing breeding conditions by remaining flexible in the amount of time allocated to foraging versus other activities. We monitored six black-legged kittiwake colonies in Chiniak Bay, Kodiak Island, Alaska over a five-year period. Breeding success was initially high (2001-03) relative to 2004 and 2005 when ~10,000 kittiwake pairs produced less than 1/10th of a chick pair⁻¹. Given the extent of the breeding failure, and an absence of disease epidemics, increased human disturbance or predation, we applied multilevel, mixed, regression models to assess the hypothesis that the collapse in breeding success was primarily due to changes in prey availability. Under this hypothesis, we predicted that longer foraging trips would be associated with reduced breeding performance in cohorts of kittiwakes – groups marked with radio-transmitters at the same colony in the same year. Results revealed little variation at the cohort-level in either response variable with hatching and fledging success explaining none or < 2% of the total variation in foraging trip-durations made during the incubation and early chick stages, respectively. Our results expose the unreliability of using indirect evidence to implicate prey availability as the primary cause of major breeding failures. As a case-in-point, we used (e.g.) the extent of the breeding failure and an absence of increased predation to implicate prey availability. We recommend that long-term monitoring studies consider in their study designs and implementations competing hypotheses that might explain major reductions in breeding success.

EFFECTS OF BROOD SIZE AND NESTLING STATUS ON ADRENAL RESPONSIVENESS AND BEHAVIOR OF BLACK-LEGGED KITTIWAKE CHICKS.

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The classic model of sibling rivalry holds that the size advantage of an older chick allows it to assert dominance and obtain a disproportionate share of food from the parents. The outcome is often manifested as significantly elevated levels of circulating corticosterone in the younger chick. However, in many avian species corticosterone levels of chicks do not vary in accordance with brood size or status. We studied the adrenocortical responsiveness and behavior of free-living black-legged kittiwake chicks (*Rissa tridactyla*) in Chiniak Bay, Alaska in 2004 and 2005. Our objectives were to determine whether (1) baseline and stress-induced levels of corticosterone of kittiwake chicks vary within or among nests, and (2) rates of begging and provisioning vary within or among nests. We sampled broods for blood in 2004 ($n = 9$ pairs, 15 singletons) and 2005 ($n = 29$ pairs, 31 singletons) and monitored the behavior of chicks in 2005 ($n = 4$ pairs, 4 singletons). While sibling aggression was witnessed, neither baseline nor stress-induced levels of corticosterone varied by status or brood size ($P > 0.05$), nor did rates of begging or provisioning ($P > 0.05$). Results suggest adrenocortical responsiveness and behavior of kittiwake chicks are not affected by brood size or nestling status. However, in both seasons, productivity was very low (0.03 ± 0.01 fledglings *nest attempt⁻¹) and all chicks exhibited high corticosterone levels that were comparable to those of food stressed chicks. Such high levels may have masked differences that might occur in less austere conditions.

LOW-LEVEL AERIAL SURVEYS OF MARBLED MURRELET NESTING HABITAT: A REVIEW OF THE PROTOCOL AND APPLICATION ON THE NORTH COAST, BRITISH COLUMBIA

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The use of a helicopter for low-level surveys of forest canopies has become a cost-effective, standard method for assessing nesting habitat of Marbled Murrelets (*Brachyramphus marmoratus*) in British

Columbia. The method gives a “murrelet’s eye” view of the canopy, allowing a quantified assessment of features, such as potential nest platforms and epiphyte development, which are not included in forest cover maps, satellite images or air photos. Other important features assessed from the helicopter include: vertical canopy complexity, tree size, tree species, age class of stand, and topography. Features are ranked in a 6-class, non-linear system which has been thoroughly field-tested throughout coastal BC. We review key aspects of the survey protocol and its strengths and weaknesses. Low-level aerial surveys have proved reliable when tested by comparing actual nest sites with randomly-located points. We describe one application of the method: testing two nest-habitat algorithms in the North Coast region in BC. One algorithm was designed for BC-wide application by the Canadian Marbled Murrelet Recovery Team and the other was a regional algorithm designed specifically for the North Coast. Both algorithms performed well in predicting the presence of canopy features associated with nesting habitat but were less successful in predicting the absence of these features. The helicopter surveys also provide insights into the habitat parameters most strongly associated with likely nesting habitat, and can be applied to both patch (e.g., 3 ha) and polygon (10s – 100s ha) spatial levels.

RELATIONSHIPS AMONG PISCIVOROUS SEABIRDS, CLIMATE VARIABLES, AND SEA ICE IN THE PRIBILOF ISLANDS, BERING SEA

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As part of Alaska Maritime National Wildlife Refuge’s monitoring program, timing of nesting events and productivity of piscivorous kittiwakes (*Rissa tridactyla* and *R. brevirostris*) and murres (*Uria aalge* and *U. lomvia*) were studied in the Pribilof Islands 1975-2006 to document relationships with fluctuations in the marine environment. Timing and productivity for the two species of kittiwakes were strongly correlated with each other and between St. George and St. Paul islands. Similar results were found between the two species of murres, but the two genera were not strongly correlated with each other. These results suggest environmental factors were operating at broader than local-island scales. Kittiwakes bred progressively earlier during the study, but significant trends were generally not evident for murres (except thick-billed murres at St. Paul nested progressively later). Kittiwake hatch dates were positively related to sea surface temperatures (SST) and negatively related to sea ice extent (SI); i.e. they nested earlier in cool springs. For murres, relationships between timing of nesting and the two measures of spring conditions were not evident. Productivity of kittiwakes was negatively related to spring SST (but not summer SST) and positively related to SI. Productivity of murres also was negatively related to spring SST and also summer SST. Murre productivity did not seem to be related to SI. These fundamental relationships provide insight into how the eastern Bering Sea ecosystem is responding to climate variability and change.

STATUS AND BREEDING BIOLOGY OF THE RED-FOOTED BOOBY IN THE SOUTH CHINA SEA

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The Red-footed Booby *Sula sula*, the smallest of the *Sulidae*, has a pan-tropical distribution and breeds on coral and volcanic islands where it nests in trees and breeds annually. Compared to elsewhere in the world, little is known about the ecology of Red-footed Boobies on the Xisha Archipelago, South China Sea. This study of Red-footed Boobies was carried out from 2003 to 2004. Random sampling was used to estimate the breeding population size, which was determined to be about 35,500 pairs. This is approximately 10% of the world population. The study of breeding ecology involved investigating breeding habitats, chick growth pattern and rate, breeding success, breeding

regime, food supplied to chicks and feeding frequency. The results are compared with those from colonies elsewhere in the world. Detailed measurements of adults and juveniles enabled comparisons to be made with colonies elsewhere, although some difficulties were encountered due to different measuring techniques. These measurements show that Red-footed Boobies appear to occur in two size groups, with Dong Island birds being in the smaller one. The main threat to the colony is a herd of approximately 100 introduced cows which preferentially eat *Pisonia* tress, especially new growth. The result in time will be the destruction of the forest that the boobies use for nesting.

MONITORING CORMORANT POPULATIONS IN SOUTHERN CALIFORNIA IN 2005-06.

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In 2005-06, University of California, Santa Cruz, resumed long-term, annual monitoring of southern California cormorant colonies with aerial photography. Humboldt State University conducted similar monitoring from 1991 to 2003. Digital photographic and counting methods were developed, and individual nests were counted for 2-3 monthly surveys per year. Highest subcolony totals were used for an annual index of breeding population size at 15 sample (of 27 active) Brandt's Cormorant (*Phalacrocorax penicillatus*) colonies, and five (of six active) Double-crested Cormorant (*Phalacrocorax auritus*) colonies. Nest totals for most sample colonies increased from 2005 to 2006. For Brandt's Cormorants, 2006 nest totals for sample colonies appear similar to 1991 (highest earlier totals), with some colony shifting. Vizcaino Point South was the largest colony (>3,000 nests in 2006); other colonies with more than 1,000 nests counted were Prince Island, Gull Island, and Dutch Harbor Area. The remnants of Sandpiper Pier, one of only two nearshore colonies south of Point Conception, were dismantled and replaced with new structures in late 2005. For Double-crested Cormorants, nest totals remain lower than 1991 totals. Prince Island was the largest colony counted (198 nests in 2006); the West Anacapa Island colony was monitored separately by California Institute of Environmental Studies. In 2006, we also detected nesting by Brown Pelicans (*Pelecanus occidentalis*) at Prince Island, last documented in the early 1960s. Annual monitoring is valuable for assessing cormorant population trends, and seabird responses to variable marine conditions and various anthropogenic impacts (e.g., oil spills, organochlorine pollution, colony disturbances, restoration projects).

POPULATION STATUS OF COMMON MURRES IN NORTHERN CALIFORNIA, 1996-2004

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For the 1996-2004 period, Common Murre (*Uria aalge*) population size and trends in northern California (from the Oregon border to Point Arena) were examined using annual aerial photographic surveys of breeding colonies. Similar aerial survey monitoring has occurred since 1979 for comparison. Whole-colony counts were determined for all colonies for 1997, 1999, 2001, 2003, and 2004, while only sample colonies were counted for 1996, 1998, 2000, and 2002. The highest total count (211,400 birds) occurred in 2004 and reflected about 176,500 breeding pairs. Since 1989, most colonies from the Oregon border to Cape Mendocino were stable or increased, including the four largest colonies at Castle Rock (2004 count >80,000 birds), and False Klamath, Green, and Flatiron Rocks (2004 counts >20,000 birds). However, due to human disturbance and other factors, Redding Rock declined dramatically from a high of 1,632 birds counted in 1989 to less than 100 birds in 2002-04. The murre

population south of Cape Mendocino represented less than 10% of the northern California total, but has increased steadily since 1989, with formations of five new colonies (Kibesillah Rock, Newport Rocks, Goat Island Area, Casket Rock, and White Rock) at the southern end of this region. However, no murrens attended Casket Rock during surveys in 2004 to 2006 or Kibesillah Rock during surveys in 2006, possibly due to human or avian disturbance. No murre colonies currently occur between Point Arena and Point Reyes.

A REVIEW OF SEABIRD BYCATCH IN GILLNET FISHERIES OF BRITISH COLUMBIA: 1963 - 2005.

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Mortality of Marbled Murrelets (*Brachyramphus Marmoratus*) as a result of interactions with commercial gillnet fisheries in British Columbia was evaluated. We review past fishery observer data and fishing effort. The number of days fished by this fleet has declined a total of 86% from 1963 to 2005. Since 1993, the majority (50-80%) of fishing effort has occurred on the north coast. In contrast, only 8 % of fishery observer effort from 1995 to 2005 focused on the north coast, the remaining effort took place in fisheries on the west coast (73%) and east coast (16%) of Vancouver Island. Between 1995 and 2005 a total of 934 birds (33 alive; 3.5%) have been observed caught by fishery observers on board salmon gillnet vessels. Of the 934 seabirds entangled, 503 have been identified including 333 Common Murres (66%), 120 Rhinoceros Auklet (24%), 14 Pigeon Guillemots (3%) and 11 Marbled Murrelets (2%). The remaining 5% represent a variety of different species. We provide bycatch rates by management area and time of year for all fisheries in which fishery observers were present. The highest bycatch rates occurred in Management Area 11 in 1997 (0.9587 birds per net hour) and in 2000 (0.5289 birds per net hour). The percent species composition of seabirds entangled changes seasonally. Gillnet fishing in close proximity to seabird colonies and feeding areas leads to increased bycatch rates. Estimated annual seabird bycatch by management area and season will be explored.

AN INTRODUCED PREDATOR ALTERS ALEUTIAN ISLAND PLANT COMMUNITIES BY THWARTING SEABIRD NUTRIENT SUBSIDIES FROM SEA TO LAND

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The effects of introduced species have traditionally been studied within the framework of trophic cascades, but introduced species may also influence communities via non-trophic routes. We quantified how the introduction of foxes onto the Aleutian Islands indirectly transformed plant communities by reducing abundant seabird populations, thereby disrupting nutrient subsidies vectored by seabirds from sea to land. Fox-infested islands had soils significantly lower in phosphorus and nitrogen and plants low in tissue nitrogen. Soils, plants, slugs, flies, spiders, and bird droppings on these islands had low $\delta^{15}\text{N}$ values indicating that these organisms obtained nitrogen from internally derived sources rather than marine sources transported by seabirds. Fox-free islands supported lush graminoid-dominated plant communities while fox-infested islands supported low-lying forbs and dwarf shrubs. Experimental augmentation of nutrients on a fox-infested island over four years caused a 24-fold increase in graminoid biomass and a shift toward a graminoid-dominated community typical of fox-free islands. These results indicate that introduced species can influence plant productivity and composition through complex interaction web pathways involving both top-down forcing and bottom-up nutrient exchanges across systems.

USING A REMOTE THERMAL IMAGING CAMERA TO OBSERVE BURROW-NESTING SEABIRDS ON CASTLE ROCK NWR IN NORTHERN CALIFORNIA

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Investigations of breeding behavior and breeding performance of the Cassin's Auklet (*Ptychoramphus aleuticus*) and Rhinoceros Auklet (*Cerorhinca monocerata*) are hindered by their crepuscular or nocturnal colony activity and burrow-nesting habits. In addition, many colonies cannot be accessed during the breeding season because of disturbance to burrow-nesting habitats and sensitive surface-nesting species such as murrelets and cormorants. In 2006, we used a remotely controlled video camera to assess efficacy and acquire information on these species at a colony where potential disturbance prevents researcher access during the breeding season: Castle Rock National Wildlife Refuge in northern California. This video camera used thermal imaging technology which is sensitive to heat gradients created by the birds and can detect warm air escaping entrances of occupied burrows without additional illumination. Observations included auklets arriving and departing burrows as well as intraspecific and interspecific interactions, including those with potential predators. We are currently assessing a fixed-plot methodology to document and quantify these behaviors. Burrows that appeared warm on camera (occupied) were counted and can be used in calculating occupancy rates and attendance patterns. Together with bird observations and off-season burrow assessments, these counts could be used to produce auklet breeding population estimates on Castle Rock. The ability of the thermal-imaging camera to distinguish auklet-sized species from each other is closely related to the distance between birds and the camera. In this study, with the longest focal length lens available, this distance was effectively limited to 50 meters. Foggy conditions interfered with visibility.

EFFECTS OF GILL-NET FISHING ON MARINE BIRDS IN A BIOLOGICAL HOTSPOT: APPLICATION OF SURVEYING SEABIRDS AT-SEA

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Marine biological hotspots, or areas where high abundances of species overlap in space and time, are ecologically important areas because energy flow through marine food webs, a key ecosystem process, is maximized in these areas. I investigated whether top predators aggregated at persistent spawning sites of a key forage fish species, capelin (*Mallotus villosus*), on the northeast coast of Newfoundland during July and August 2000-2003. By examining the distributional patterns of top predators through at-sea surveys at multiple spatial scales, I found that the biomasses of birds, dominated by Common Murres (*Uria aalge*), and mammals, dominated by whale species, were concentrated along the coast, with a biological hotspot forming near two persistent spawning sites of capelin in all years. The formation of this hotspot was well-defined in space and time from mid-July to mid-August, likely coinciding with the spawning chronology of capelin. Within this hotspot, there was a high spatial and temporal overlap of Common Murres and gill nets set to capture Atlantic cod (*Gadus morhua*). This resulted in the entanglement of breeding murrelets in gill nets while feeding on spawning capelin. Despite acknowledged uncertainty of by-catch mortality, estimates for the larger regional-scale area (1,936-4,973 murrelets/year; 0.2-0.6% of the nearby Funk Island breeding population) underestimated mortality relative to estimates within the fine-scale hotspot (3,053-14,054 murrelets/year; 0.4-1.7%). Although fishing effort for Atlantic cod has declined substantially since the groundfish moratorium in 1992, chronic, unnatural, and additive mortality through by-catch continues in coastal Newfoundland. Restricted use of gill nets within this and other hotspots during the capelin spawning period would minimize murre by-catch and maintain ecosystem integrity.

DIET CHANGES IN A SEABIRD COMMUNITY: SYSTEM SHIFT, OR CHANGING “AVAILABILITY” OF PREY?

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Twelve years of data on diet and productivity of four species (Atlantic Puffin *Fratercula arctica*, Razorbill *Alca torda*, Arctic Tern *Sterna paradisaea* and Common Tern *S. hirundo*) breeding on Machias Seal Island, Bay of Fundy, suggest a system-wide shift in the food-web of the near-surface water column. In 2000 the dominant prey (Atlantic Herring *Clupea harengus*) declined sharply in the diet of all species except Razorbill; since 2001 the other 3 species have taken chiefly euphausiid shrimp and larval forage fish. Since shrimp are a major food of herring, the puffins and terns now feed one trophic level lower than before. The persistence of herring as a major component of the diet of Razorbills (the deepest diver in this community) implies a change in herring behavior, rather than decreased abundance of the stock, and highlights the difficulty of defining prey “availability”. Possible factors contributing to this shift are explored, including changes in the herring stock, changing oceanographic conditions, and combinations of the two.

INTEGRATED WEIGHT LONGLINES WITH PAIRED STREAMER LINES – BEST MANAGEMENT PRACTICE FOR DEMERSAL LONGLINE FISHERIES

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We tested traditional (unweighted or UW) and integrated weight (IW; 50 g/m lead) longlines with and without paired streamer lines (PS; Figure 1) on two autoline freezer longline vessels targeting Pacific cod in the Bering Sea, Alaska, USA. Our objective was to evaluate IW as a practical seabird mitigation technology relative to paired streamer lines using multiple criteria: catch rates of seabirds and fish, seabird behavior, gear sink rate and performance. Integrated weight longlines used in combination with paired streamer lines dramatically decreased the catch rates of both surface foraging (100%) and diving seabirds (97%) with no negative impact on target fish catch or other bycatch species. IW longlines reduced risk to seabirds by halving the distance astern that birds have access to sinking baits (41 to 49 m) and performed better than traditional UW line. Combined with paired streamer lines with an aerial extent of 60 m, seabirds were excluded from the area around the sinking longline until it was well beyond the depth range of surface foraging seabirds (2 m). These results strongly suggest that that 50 g/m integrated weight longlines deployed with paired streamer lines with an aerial extent of 60 m, constitute the most effective seabird bycatch mitigation technique for autoline longline systems. These data also show that attack rate is an inconsistent predictor of seabird bycatch rates, and therefore attack rate alone is a poor proxy in trials of seabird mitigation technologies.

DON'T MESS WITH BILL: LACKING DECOYS AND DECORUM, HORNED PUFFINS (*FRATERCULA CORNICULATA*) ATTEMPT TO COLONIZE THE ALASKAN ARCTIC

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The expansion and contraction of seabird breeding ranges can provide some of the first and most visible evidence of ongoing changes in marine ecosystems. At Point Barrow, Alaska, Horned Puffins were rare before 1950, a regular visitor in the 1970s and first recorded breeding in 1986 on Cooper

Island, 25 miles east of Point Barrow. Until 2003 breeding was irregular and typically involved only a single pair, but in 2003-2006 multiple pairs bred annually with a concurrent increase in prospecting nonbreeders. While earlier annual snowmelt was needed for the region to provide puffins sufficient access to nesting cavities, an increase in late summer SST (+0.8 °C /decade since 1982) and a decrease in August ice extent have created a more subarctic foraging environment for the species. Linear growth of puffin chicks on Cooper Island is as high as in the Gulf of Alaska (>14 g/day). The 450 km range expansion has affected the resident Black Guillemots (*Cepphus grylle*) as nonbreeding puffins displace eggs and kill or maim guillemot nestlings while prospecting. In 2004, 73 of the 189 guillemot nestlings were killed by puffins. The recent increase in puffin numbers has been associated with record reductions of the summer pack ice and predicted future ice reductions will likely result in increased colonization.

DON'T LET THE SUN GO DOWN ON ME: COLONY ATTENDANCE OF BLACK GUILLEMOTS (*CEPPHUS GRYLLE*) DURING UNLIMITED AND RAPIDLY DECREASING DAYLIGHT

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During the 2006 breeding season we examined colony attendance at a Black Guillemot colony off northern Alaska (71°14'N) where the sun is above the horizon from the time birds return to the colony in early June until 1 August, when most nestlings have hatched. Daylight decreases 40 percent from 1 August to 10 September when the last chicks are fledging so that photoperiod constraints are minimal before hatching and highest during the period of presumed maximum energy demands. Throughout the summer guillemots had a single daily period of colony attendance with birds rarely seen sitting near nest sites at other times. In the pre-egg stage the attendance period lasted from approximately midnight to early afternoon; during incubation it decreased to 0400 - 1200; and, after an initial increase in duration at hatching, decreased during the chick period from >10 h to <8 h, gradually shifted to midday. No colony attendance occurred after 20 August. While the timing and duration of attendance during the nestling period is well explained by photoperiod constraints, the factors favoring a "nocturnal" arrival and attendance in the pre-egg and incubation periods are less obvious. Likely explanations include diel cycles in prey availability or predator activity.

NEW PLACES, NEW PEOPLE, FEWER FEET: COASST EXPANDS TO ALASKA.

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The Coastal Observation and Seabird Survey Team (COASST) is a citizen science program focusing on beached birds as indicators of coastal marine environmental health operating in the Pacific Northwest since 1999. In May of 2006, COASST expanded to the 'last frontier,' starting more than 40 beaches scattered over five communities and five Alaska Maritime National Wildlife Refuge sites stretching from Sitka in Southeast to St. George in the Bering Sea. Despite lack of sun, ice on the beaches, and cold temperatures, 50 volunteers including school groups, native Alaskans, federal and state biologists, and coastal citizens have already signed up to monitor beaches monthly. To date, more than 20 species have been found, six of which are new to the program. Northern Fulmars, Black-legged Kittiwakes, and Glaucous-winged Gulls top the list of finds. In addition to species differences, Alaskan carcasses are more likely to be partial, often missing breast, head, and/or feet as the relatively voracious foxes troll beaches for their next beach-cast meal. This also means that telling Common from Thick-billed Murres – from wings alone – is a challenge. The Alaskan expansion will create a baseline – the normal pattern – against which the effects of oil spills, fishery interactions, and large and small-scale

climate events can be measured. At the same time, COASST engages coastal citizens in the deductive scientific process, allowing them to proactively monitor and learn about their local environment.

THE COLD, ROCKY TRUTH: LASTING EFFECTS OF HABITAT SHIFTS ON CHICK SURVIVAL IN FORK-TAILED STORM-PETRELS IN THE ALEUTIAN ISLANDS DUE TO INTRODUCED FOXES

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Fork-tailed Storm-Petrels (*Oceanodroma furcata*) were dramatically impacted by foxes introduced to the Aleutian Islands during the last two centuries. Predation by foxes caused not only population declines but also a shift in nesting habitat use in surviving populations, with birds moving from predominately soil habitat to rock habitat to escape predation. Although foxes have now been removed from many islands for decades, storm-petrels have not yet returned to their original nesting habitat. Because nesting habitat can affect survival and reproductive success, this habitat shift may have important consequences for storm-petrel recovery. We investigated how nesting in rock habitat influences reproductive success in Fork-tailed Storm-Petrels on Kasatochi Island, Alaska, where foxes were historically introduced and since removed. We quantified physical and microclimatic characteristics of nest sites that varied in soil and rock composition and related these features to reproductive success in 2005 and 2006. Temperature and humidity within nests differed from one year to the next, but in both years rockier nest sites were associated with colder temperatures. Despite dramatic differences in chick survival between the two years, nest temperature was a significant predictor of chick success in both years. Our results suggest that nesting in rocky nest sites may depress chick survival and therefore shifts to rocky nesting habitat because of introduced foxes may influence breeding success in recovering storm-petrel populations.

TIME BUDGETS OF CHICK-REARING COMMON MURRES (*URIA AALGE*) AT DEVIL'S SLIDE ROCK, CALIFORNIA, 1999-2006

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From 1999-2006, we calculated time-budgets for Common Murres (*Uria aalge*), including co-attendance of pairs and chick-provisioning rates, at Devil's Slide Rock, California. Each year, 12 to 15 chick-rearing pairs of murres were monitored all day on three days temporally separated across the nestling period. We recorded adult arrivals, departures, and prey deliveries to nestlings. We measured time spent by adults in co-attendance and chick-provisioning in relation to breeding productivity, breeding phenology, and ocean conditions. Average time in co-attendance was less than 10% in three of the eight years (2003, 2005, and 2006) and was associated with lower breeding success, reduced upwelling and elevated sea surface temperatures. From 1999-2002 and in 2004 average time in co-attendance ranged from 17 to 23% and was associated with higher breeding success. Adults provisioned their chicks less frequently in years with the lowest breeding productivity (2005 and 2006: 0.3 chicks per pair). These data suggest that murres breeding at Devil's Slide Rock spent more time foraging in years with poor ocean conditions or years with low prey availability. This study demonstrates the value of monitoring co-attendance rates to detect changes in the marine environment on an inter-annual basis.

ENERGY GAIN AND EXPENDITURE INFLUENCE SURFACE PAUSE INTERVALS IN AN ARCTIC SEABIRD

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For diving birds, the role of prey in determining dive characteristics is poorly known. Dives exceeding the aerobic dive limit (ADL) are thought to be costly because they extend the inter-dive surface time. Nevertheless, it has been argued that dives exceeding ADL, combined with short surface pauses, may be an efficient strategy if (1) prey density outweighs the cost of anaerobiosis, or (2) the probability of losing contact with an ephemeral prey source during transit to the surface is high. To test these ideas, we examined surface pause duration, dive duration and dive depth during dive bouts of parental Thick-billed Murres (*Uria lomvia*) immediately prior to the delivery of a prey item to their chick. There was a strong, exponential relationship between surface pause duration and both dive depth and dive duration. The relationship was slightly stronger with dive depth and with succeeding rather than preceding surface pauses (i.e. surface pauses were “reactive”; depth: $R^2 = 0.77$ vs. 0.75 ; duration: $R^2 = 0.72$ vs. 0.70). Dive depth was a better predictor of surface pause duration than dive duration, presumably because it better predicts energy expenditure. Surface pause duration decreased weakly with prey mass ($R^2 = 0.01-0.04$). For a given depth, dive duration increased with prey mass ($R^2 = 0.17$). For a given dive depth, both dive duration and rate of prey acquisition were higher for benthic items, presumably because benthic dives involved less energy expenditure. The importance of energy expenditure was also shown when handicapped murres showed reduced surface pause duration for a given dive duration. The relationship between surface pause, dive depth and dive duration varied with prey quality and type, suggesting that these parameters may be useful indicators of prey abundance. Our results show that energy intake and energy expenditure both influence surface pause, dive depth and dive duration in Thick-billed Murres

SEABIRD FORAGING BEHAVIOUR INDICATES PREY TYPE

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It is unclear whether marine predators that are dietary generalists actively change their behaviour to search and capture desired prey items, or whether they move randomly through a habitat, consuming prey items as they are encountered. Understanding the decisions underlying foraging strategies of generalist predators is important for accurately using their diets as indicators of changes in prey availability. To investigate how a generalist marine predator modifies its foraging behaviour for different prey types, we attached time-depth-temperature recorders to chick-rearing Thick-billed Murres (*Uria lomvia*; n = 23 in 2004; n = 33 in 2005; n = 80 in 2006) at Coats Island, Nunavut. Dive behaviour for the following prey: fish doctor, squid, amphipods, daubed shanny, sand lance and Arctic shanny was discriminated from each other at the 80% or 95% confidence level by minimum convex polygons on a discriminant analysis of dive variables and, therefore, were considered prey items associated with ‘specialized’ dive behaviour. Specifically, amphipod were captured after V-shaped dives near the colony with a slow descent rate, squid were captured after deep V-shaped dives and fish doctor were captured after a long series of U-shaped dives in warm water far from the colony. Dive behaviour for snakeblenny and daubed shanny overlapped, with the former taken at shallow depths far from the colony and the latter taken either at shallow depths far from the colony or deep depths close to the colony. The dive behaviour for Arctic cod, capelin and sculpin overlapped with each other and with other prey items and, therefore, were considered prey items associated with ‘generalized’ dive behaviour. In general, V-shaped dives preceded deliveries of pelagic prey items and U-shaped dives preceded deliveries of benthic prey items. Our results strongly suggest that thick-billed murres use stereotyped behaviour to forage for different prey types, presumably based on previous knowledge about the foraging strategies that maximize foraging efficiency for a given prey type.

TIMING AND AVAILABILITY OF KRILL REGULATES PREY CONSUMPTION BY CASSIN'S AUKLETS IN CENTRAL CALIFORNIA.

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We examined the hypothesis that timing and availability of krill regulates prey consumption by Cassin's auklets (*Ptychoramphus aleuticus*). We tested this hypothesis by conducting research cruises to determine the abundance and distribution of krill in 2004 (May-October) and 2005 (February-October). This hypothesis is important because prior studies have suggested that 1) wintertime oceanographic conditions influence the availability of (*E. pacifica*) in the water column, and 2) there are temporal differences in the availability of (*E. pacifica* and *T. spinifera*). We found that (*E. pacifica* and *T. spinifera*) were the two most abundant species and accounted for 80% and 12% of the krill in the samples, respectively. (*E. pacifica*) in the upper water column was present year-round, with juveniles present in all samples except in winter. (*T. spinifera*) were absent from the upper water column in winter and mid-spring. With the exception of these dates, juveniles were present in all samples. Adult stages of *E. pacifica* occurring in the upper water column during the day were associated with cold waters during strong upwelling events. Male and female (*E. pacifica*) were found near the surface during April and June 2005. Preliminary evidence suggests that (*E. pacifica*) spawns early in the year relative to (*T. spinifera*). Highest abundance of mature females was found in spring for (*E. pacifica*) and early-summer for (*T. spinifera*). Timing and availability of krill resembles average "prey switching" pattern observed in prey consumed by Cassin's auklets on the Farallones Island.

SEABIRD DISTRIBUTION AND ABUNDANCE AT CORDELL BANK, CA ASSOCIATED WITH CHANGES IN REGIONAL OCEANOGRAPHIC CONDITIONS.

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Cordell Bank, CA provides optimal conditions for ocean productivity and seabird foraging: a shallow bank situated on the edge of the continental shelf, located in a strong upwelling zone within the California Current System (CCS). Within the CCS, 2005 and 2006 represent unique years, with late onset of upwelling, followed by weak and intermittent upwelling. The resulting response of the marine ecosystem to these changes in atmospheric and oceanographic conditions is reflected in seabird patterns observed as part of a monthly monitoring program of the Cordell Bank system. Preliminary examination of data suggests a shift in distribution and abundance of seabirds, with responses varying depending on foraging strategy. Cassin's auklets (*Ptychoramphus aleuticus*) are one of the most abundant species found in the waters surrounding Cordell Bank; however, the abundance of this planktivorous specialist decreased in 2005-2006, likely due to a lack of krill prey. In contrast, abundances of some opportunistic scavenging species (e.g., shearwaters, albatrosses) appear to have increased in 2006 in the Cordell Bank region. In 2006, we observed a change in the distribution of some piscivorous species (Common murre, *Uria aalge*, Brown pelican, *Pelecanus occidentalis*) from nearshore to offshore environments. These observations suggest suites of species may be responding differently to changes in the pelagic prey community in these offshore waters. These results indicate that regional changes in atmospheric and oceanographic conditions are reflected in local changes in seabird distribution and abundance, which can provide insight into the overall abundance and re-distribution patterns of seabirds within the CCS.

LIGHT LOGGERS ILLUMINATE THE MIGRATORY TACTICS OF NORTHERN GANNETS ON AND OFF BEATEN OCEAN PATHWAYS.

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We used light-temperature loggers to investigate the migratory tactics of breeding adult gannets at 3 Canadian colonies, including successive migrations by individuals. We equipped gannets from the largest North American (Bonaventure Island, Quebec) and the most northerly and southerly (Funk Island and Cape St. Mary's, Newfoundland) colonies in the Northwest Atlantic. Gannets exhibited short (northeast US), moderate (southeast US) and long (Gulf of Mexico) distance migrations. Similar proportions of gannets from each colony wintered on the Atlantic coast and in the Gulf of Mexico, though a higher proportion of Bonaventure gannets wintered along the southeast US coast. Sexes showed similar migratory diversity. Individuals exhibited remarkable wintering area fidelity and temporal consistency of travel. Two of 10 Newfoundland gannets exhibited unexpected migrations to West Africa. Contrastingly, no (n=26) Bonaventure gannets did so. Interestingly, both of the trans-Atlantic migrants departed from eastern Canadian waters within 2 days of one another in late October 2005, likely associated with weather events linked to large scale ocean climate. Both gannets crossed the ocean in 3 – 4 days, possibly owing to energetic pressures to reach inshore eastern Atlantic foraging sites. Geo-logger evidence from the eastern Atlantic has recently identified West Africa as a major wintering area for breeding gannets from the largest North Sea colony (Bass Rock). The gannets' trans-Atlantic routes are likely related to their exploitation of large scale atmospheric pressure systems. We discuss the implications of migratory tactics for spatial population dynamics. We also consider potential influences of changing ocean climate on migration patterns.

MARINE HABITAT USE OF BLACK-FOOTED AND LAYSAN ALBATROSSES OFF ALASKA: INTER-SPECIFIC VARIATION DURING THE NON-BREEDING SEASON

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Marine habitat use of black-footed (*Phoebastria nigripes*) and Laysan (*P. immutabilis*) albatrosses during the non-breeding season is poorly understood. We, therefore, integrated satellite-tracking of albatrosses during the non-breeding season with remote sensing data to compare marine habitat use between species. During July to November 2005 and 2006 we tracked 7 black-footed (*Phoebastria nigripes*) and 18 Laysan albatrosses (*P. immutabilis*) captured at-sea in the Aleutian Islands, Alaska. Even within Alaskan waters we observed strong inter-specific differences in distribution and habitat associations. Generally, Laysans remained nearer to the Aleutian Islands and west of the capture location compared to black-footeds that ranged more widely and traveled east of the capture site. Laysans were strongly associated with oceanic waters remaining primarily offshore of the continental shelf and slope. In contrast, black-footeds were not closely associated with one bathymetric domain but rather spent relatively equal proportions of time over shallower continental shelf and slope waters. Laysan movement was limited to cool sub-arctic waters (<15°C); black-footeds, however, ranged into warmer tropical waters (>15°C). Chlorophyll a concentration in waters used by the two species was similar on average, although black-footeds did travel to oligotrophic waters of the sub-Arctic transition domain not visited by Laysans. Overall, black-footeds distribution and habitat use was more varied than that of Laysans. These results demonstrate inter-specific differences in habitat use during the non-breeding season and improve our understanding of their ecological relationships during the non-breeding season.

CHARACTERIZING OCEANIC HABITAT USE BY SEABIRDS USING REMOTE SENSING DATA.

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Understanding the linkages between physical forcing and the presence or absence of biological organisms is of key importance to discerning hot spots in the oceans. Here we demonstrate the use of remote sensing observations from multiple satellite platforms to identify and characterize physical features in regions of enhanced seabird activity. We have developed a toolbox for automated extraction of variables derived from remote sensing measurements along instrumented seabird track lines. The integration of satellite oceanographic monitoring and data from large-scale electronic tagging experiments can be used to conduct a census of biological hot spots, to understand behavioral changes and species interactions within hot spots, and to differentiate the preferred pelagic habitats of a variety of seabird species.

EVALUATING CURRENT THREATS TO CALIFORNIA LEAST TERNS

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California Least Terns (*Sterna antillarum brownii*) was listed as endangered in 1970 due to the loss of suitable nesting habitat, increased predation, and human recreation. According to a recent review by the USFWS, the California Least Tern (CLT) population is increasing despite very low reproductive output. One generally accepted cause for the low reproductive output is high chick mortality. This mortality may stem from threats outlined above, or may be a result of other pressures, e.g. changes in abundance or distribution of prey base, an increase in algal blooms or other toxins, and continued degradation of foraging habitat. The USFWS has acknowledged that the species has become “conservation reliant” and will not persist without intensive management. To effectively manage this population, there must be a better understanding of the relative impact of the many threats this species faces across different colonies. As a first step to tackle this question, we reviewed existing demographic data from two large CLT colonies, Coronado and Camp Pendleton. We present results from an analysis of long term data on chick mortality obtained from on-site monitoring. We found that Camp Pendleton has a high incidence of dead or sick chicks that are weak and underweight. At Coronado, direct attacks on chicks and eggs by Gull Bill Terns, a novel predator, were substantial. These results highlight the importance of considering multiple threats to this at-risk population and the need to recognize how threats vary across temporal and spatial scales within and among nesting sites.

EVIDENCE FOR SYMPATRIC SPECIATION IN MADEIRAN STORM-PETRELS

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The importance of sympatric speciation - the evolution of reproductive isolation between geographically codistributed populations - in generating biodiversity is highly controversial. Initial theory indicated that it can occur only under special circumstances, but recent models suggest it may be more plausible. Whereas clear examples of sympatric speciation exist for plants, insects and fishes,

only one possible case - speciation via host switch in brood parasitic indigobirds (*Vidua* spp.) - has been described for tetrapods. Madeiran storm-petrels (*Oceanodroma castro*) nest on tropical and subtropical islands throughout the Atlantic and Pacific Oceans. On at least five archipelagos, separate populations breed on the same islands in different season. Monteiro and Furness (1998) suggested that seasonal populations in the Azores represent reproductively isolate species that arose sympatrically. We compared variation in the mitochondrial control region and seven microsatellite loci among 569 Madeiran storm-petrels sampled throughout their range. We found clear evidence for genetic divergence among petrels from different archipelagos, as well as between seasonal populations within four archipelagos. The population trees generated from mitochondrial DNA and microsatellites both indicate that seasonal populations within archipelagos are more closely related to each other rather than to populations from the same season from other archipelagos. Thus, seasonal populations appear to have arisen sympatrically at least four times within this species. Furthermore, in two archipelagos, seasonal populations appear to represent reproductively isolated species. This is the first clear evidence for sympatric speciation by allochrony (separation of breeding times) in a tetrapod.

FORAGING TACTICS OF NORTHERN GANNETS: FLEXIBILITY, CHANGING ENVIRONMENTS AND OPPORTUNISTIC PREDATION.

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We studied the foraging ecology of northern gannets (*Morus bassanus*) in two colonies in eastern Canada to investigate how spatial and temporal patterns in foraging behaviour are related to prey choice and availability. To test this, gannets were equipped with GPS and other data loggers in the species' largest North American colony on Bonaventure Island in the boreal waters of the Gulf of St. Lawrence (2003) and in the northernmost and most oceanic colony on Funk Island in the low arctic waters of the Northwest Atlantic (1999, 2001, 2003, 2005). During 2003, the prey-fields around the 2 colonies were considerably different, consisting primarily of capelin, a small cold-water forage fish, in the Funk Island region and a diversity of large and small warm- and cold-water pelagic fishes in the Gulf of St. Lawrence. Prey fields in Funk Island changed from cold-water prey (1999, 2001, 2003) to warm-water prey (2005). Consequently, gannets exhibited flexible foraging tactics at the 2 colonies and between years at Funk Island to negotiate differences in prey fields. Pelagic prey (mackerel, herring, saury) was associated with much more variable flight distances and flight directions than benthopelagic prey (capelin) that was exploited in persistent near-shore spawning sites. Diving behaviour differed also in a variety of parameters. The gannets exhibited a flexibility of foraging tactics that allow them to cope adequately with changing prey and oceanographic conditions. This behavioural plasticity underlies the gannets' opportunistic predatory behaviour that is likely facilitating the current increases in North American populations.

OUT OF SIGHT, OUT OF MIND: THE IMPACT OF DERELICT FISHING GEAR ON THE MARINE FAUNA OF PUGET SOUND AND SURROUNDING WATERS.

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Derelict fishing gear--lost or abandoned commercial and recreational fishing nets, lines, pots, and traps that sit or float underwater--can remain in the marine environment for years. Manufactured for longevity, this unseen and largely unquantified type of marine debris can trap and kill marine fauna, including species of conservation concern. Since 2002, we have documented the capture and mortality of marine fauna during derelict gear recovery operations in Puget Sound and surrounding waters.

Specimens collected during gear recovery were identified to the lowest possible taxon as nets were hauled onboard, during laboratory dissections, or using osteological characters of skulls and post-cranial material. Invertebrates were the most abundant specimens ($n \approx 6400$), followed by fish ($n \approx 850$), birds ($n \approx 120$) and mammals ($n \approx 12$); however, the proportion of specimens found dead varied among marine mammals (100%), birds (100%), fishes (93%), and invertebrates (69%). The risk to marine fauna posed by derelict gillnets is influenced by factors such as net location, habitat type, water depth, net type, vintage, and dimensions, and the net's fishing potential (stretched open vs. closed). Studies underway will focus on derelict gear near hotspots (marine protected areas, haul-out sites, wildlife refuges) as well as rates of mortality and turnover of entangled taxa to refine estimates of derelict gear impact on marine species of conservation concern and to prioritize future derelict gear recovery and restoration efforts.

PROFILE OF ESTERO BAY SEABIRD COMMUNITY DURING PERIODS OF PACIFIC DECADEAL OSCILLATION PHASE CHANGE

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The Pacific Decadal Oscillation (PDO) Index has been used to quantify the warm or cool phases present in the Pacific and evident over a multi-decadal time scale. Marine organisms present in the system exhibit demographic and geographic variation in response to these thermal phase changes. We compare seabird community structure at the beginning and end of a 30-year span, correlating with possible PDO phase shifts. From 1975 to 1980, biologists from Cal Poly and California Department of Fish and Game conducted 31 seabird surveys on Estero Bay, establishing a baseline of seasonal presence and abundance of seabirds. In 2004-05 a replicate one-year study was completed. During each at-sea boat survey, all birds observed within 200m of the boat were recorded. The boat traveled at a constant rate along an established transect loop parallel to the coast and across the mouth of the bay. Analysis of variance was used to determine significant temporal and spatial differences between communities and to identify environmental predictors of community structure. The current community was found to be significantly different from the historic community with respect to apparent abundance for higher taxonomic groupings (family, sub-family and/or tribe). Groups with variance that can be significantly attributed, in part, to changes in the PDO Index over time include terns and gulls. Observer viewing conditions and seasonality were found to be significant predictors of community structure at the group level.

DIET OF RED-THROATED AND ARCTIC LOONS (*GAVIA STELLATA* & *G. ARCTICA*) IN THE SOUTHERN BALTIC SEA, NE EUROPE

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The Baltic Sea, a major Brackish sea area in NE Europe, is a major hotspot for migrating and wintering waterbirds and seabirds. One of its most important areas is the Pomeranian Bight, located at the interface between riverine freshwater and brackish/sea water. During winter and spring it holds large concentrations of Red-throated and Arctic Loons, reaching numbers of international importance. Information on their diet outside the breeding season has been scarce. Thus, a substantial sample size of by-caught loons from the Pomeranian Bight offered a unique possibility to gain information on their winter and spring diet. Results were obtained by analysis of stomach and gut contents and were compared between the bird species. The large sample size of Red-throated Loons allowed to compare the composition of their diet between sexes, seasons and years. Overall, 11 fish species from eight different families could be found. Some species were consumed in similar quantities in all analyzed periods. On the contrary, the consumption of Zander (*Sander lucioperca*) and Atlantic Herring (*Clupea harengus*) showed clear seasonal differences. The percids Zander and Ruffe (*Gymnocephalus cernuus*) were the most important prey during winter whereas herring clearly dominated the diet in spring.

Arctic Loons showed a similar diet as Red-throated Loons, but there was a tendency that small fish species such as gobies (*Pomatoschistus* spp.) were of greater importance. The observed differences gave insight on the dietary choice of both species regarding abundance, habitat, behavior and size of preferred prey.

AT-RISK SEABIRDS? SPACE AND TIME OVERLAP OF COMMON MURRES AND GILLNET FISHERIES REVEALS POTENTIAL BYCATCH

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Although there are estimates of seabird mortality rates in specific fisheries, there is less information on the bycatch risk for specific colonies. In the Pacific Northwest, common murres (*Uria aalge*) are the most abundant seabird incidentally caught in coastal gillnet fisheries for sockeye and chum salmon. We assessed whether murres from Tatoosh Island, WA, the largest known breeding colony in the state, are potentially at risk of bycatch in Canadian and U.S. waters. Potential risk was evaluated with an index of density overlap between radio-tracked murres and fisheries effort for simultaneous space-time scales. Using 300 radio-detections from 48 birds tracked over three years (1999-2001), we simulated bird abundance among three regions (offshore, inshore, centered around the colony) based on weekly post-breeding movement probabilities inferred from mark-recapture multi-strata models. Fisheries effort was summarized as boat-days/km². Region and time dependent-model averages of movement rates indicate that a majority of birds disperse away from the vicinity of the colony (86% ± 3%) and move to the inshore region (69% ± 8%) whereas few travel offshore (17% ± 7%). Fisheries are active in all three regions, with most of the annual effort concentrated inshore (60% ± 20%). The index of overlap suggests that potential risk of bycatch varies by week and region, with the highest values inshore given greater dispersal to the region and high fisheries effort. This research suggests that murres from Tatoosh Island are susceptible to gillnet fisheries, highlighting that incidental mortality in gillnets is a potential factor affecting population dynamics.

SEABIRD RESTORATION IN THE AFTERMATH OF THE SS JACOB LUCKENBACH

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The *SS Jacob Luckenbach* sunk in 1953 in the Gulf of the Farallones off the California coast. As the wreck deteriorated, it released oil, particularly during winter storms. Between 1990 and 2004, over 51,000 seabirds were estimated killed. Because there is no longer a viable responsible party, the United States Coast Guard authorized the expenditure of approximately \$19 million from the Oil Pollution Liability Trust Fund to remove oil from the wreck in 2002. Government trustee agencies then assessed the injuries to natural resources, issuing a draft and final restoration plan in 2006, as well as involving the public in project selection. The trustee agencies are currently seeking over \$25 million to implement 13 restoration projects to restore the impacted seabird species. The projects are designed to benefit waterfowl, Red-throated Loon (*Gavia stellata*), Pacific Loon (*Gavia pacifica*), Western Grebe (*Aechmophorus occidentalis*), Clark's Grebe (*Aechmophorus clarkii*), Ashy Storm-Petrel (*Oceanodroma homochroa*), Sooty Shearwater (*Puffinus griseus*), Brown Pelican (*Pelecanus occidentalis*), Double-crested Cormorant (*Phalacrocorax auritus*), Brandt's Cormorant (*Phalacrocorax penicillatus*), Snowy Plover (*Charadrius alexandrinus*), Red Phalarope (*Phalaropus fulicaria*), Common Murre (*Uria aalge*), Marbled Murrelet (*Brachyramphus marmoratus*), Ancient Murrelet (*Synthliboramphus antiquus*), Cassin's Auklet (*Ptychoramphus aleuticus*), and Rhinoceros Auklet (*Cerorhinca monocerata*). The projects are located at breeding sites in California, Alaska, British Columbia, Mexico, and New Zealand.

PROTECTING HAWAIIAN PETRELS FROM PREDATION

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The introduction of alien predators has devastated insular seabirds worldwide. Cats (*Felis catus*) brought to Hawaii in the 1700s now occupy most habitats throughout the islands, including montane and subalpine zones. We studied population genetics, diet, and bait preferences of feral cats, and developed and tested a trap-alerting device for protecting endangered Hawaiian Petrels (*Pterodroma sandwichensis*) from predation. Population genetics revealed that Mauna Kea may be a source population for feral cats that prey on Mauna Loa petrels in Hawaii Volcanoes National Park (HAVO). Assignment tests provided strong evidence for male-biased dispersal from Mauna Kea to Mauna Loa. Cats on Mauna Kea primarily preyed on birds, present in 79% of digestive tracts, whereas birds were in only 28% of samples from HAVO. Abundant birds on Mauna Kea may maintain large numbers of feral cats that disperse long distances. Abundant rodents found in Mauna Loa digestive tracts may also support cats that then take advantage of breeding petrels. We recorded over 8,000 events with remotely-triggered cameras at 4 types of food-based baits and attractants. Cats were photographed on only 5 (0.5%) occasions, all of which were at sardine bait. We developed and tested a simple trap-alerting device. These telemetry systems were effective from 16.7 km and failed in < 1% of trap-nights. The system allowed staff to respond to alerting traps, thereby reducing the amount of effort spent checking traps. Predation on Hawaiian Petrels can be reduced by understanding movements and ecology of feral cats and by improving trapping techniques.

SOURCES OF VARIATION IN THE DIET OF DOVEKIES EVALUATED THROUGH STABLE-ISOTOPE ($\delta^{13}\text{C}$ and $\delta^{15}\text{N}$) ANALYSIS: IMPLICATIONS FOR ASSESSING MARINE ECOSYSTEM CHANGE IN THE HIGH ARCTIC.

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We used stable isotope analysis (SIA) to investigate potential age- and sex-related sources of variation in the diet of Dovekies (*Alle alle*) across the breeding season. This study was conducted in Hornsund, Spitsbergen, during the summer of 2002. We measured variation in $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ values from whole blood samples taken from dovekie adults and chicks sampled across the breeding season. We concurrently measured the stable isotope values in whole chick meals in addition to identifying the species and age class of chick meal prey items. Observations were conducted on individual birds to examine variation in foraging behavior across the breeding season. There were three major findings of this study: (1) there was a strong, seasonal depletion of $\delta^{13}\text{C}$ and enrichment of $\delta^{15}\text{N}$ in both adult and chick little auk blood samples; (2) there were striking differences in stable isotope ratios between adult and chick blood samples, and (3) the SIA of chick blood varied across the chick-rearing period, whereas there was no change in either the SIA of chick meals or the species composition of chick

meals over time. We discuss the implications of these results for the use of dovekie diet as a tool to monitor marine ecosystem change in the High Arctic.

THE ISLE OF MAY LONG-TERM MURRE STUDY: FROM MUNDANE MONITORING TO SCINTILLATING SCIENCE

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After two postdocs in the Galapagos Islands, I returned to the UK in 1972 to take up an appointment to determine the factors responsible for a marked decline in the numbers of the Atlantic puffin (*Fratercula arctica*) a specialist on 0-group lesser sandlance (*Ammodytes marinus*). I selected the Isle of May, southeast Scotland, as a field site since it was one of the few colonies in the eastern Atlantic where the number of puffins was known to be increasing. However, the Isle of May also had substantial numbers of other breeding seabirds and in 1981 I expanded the study to include the Common murre (*Uria aalge*) - a species specialising on older sandlance. Initially this was a curiosity-driven project but the vagaries of funding, and the sudden rise in interest in seabird monitoring, resulted in it becoming a monitoring study, although with more emphasis on individual birds than is typical. The first part of the talk summarizes findings from the classical monitoring approach and documents the changes in fortunes, numbers and breeding performance of the murrelets over the last 25 years during which conditions have changed dramatically. The second part concentrates more on population and evolutionary ecology and the results coming from a detailed study of 7000 individually colour-banded murrelets (including 1000 breeding adults). The topics covered span the period from 'the cradle to the grave' and include results of analyses looking at plasticity of laying date, survival and recruitment of chicks, divorce and senescence.

RECOGNIZING THE RECOVERY OF THE "ENDANGERED" CALIFORNIA BROWN PELICAN.

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The Endangered Species Recovery Council submitted formal petitions to remove the California Brown Pelican (*Pelecanus occidentalis californicus*) from the list of species covered by the federal and California endangered species acts (ESA) because it is neither in danger of extinction, nor likely to become extinct within the foreseeable future. The population of California Brown Pelicans meets or exceeds historical metrics and its recovery goals. Moreover, it produces young in synchrony with environmental variables that track other species in the California Current, and has maintained an upward population trajectory for years. The subspecies will continue to encounter challenges from a variety of threats which are similar to those faced by other coastal seabirds. For example, 25-50 pelicans per year die from oil spills, but such mortality does not threaten the viability of the population. Delisting this species has been suggested since 1980 by a number of ecologists, including Lloyd Kiff, Joseph Jehl, Jr., the late Ralph Schreiber, David G. Ainley and George L. Hunt, Jr. Once delisted, pelicans will continue to be fully protected by the federal Migratory Bird Treaty Act and the California Fish and Game Code. There are many seabirds that have severe conservation problems, some of which can be solved with a strong ESA. To withstand criticism and weakening of the ESA, wildlife agencies need to identify and move on from their successes. The Brown Pelican is just such a case.

WOULDN'T IT BE NICE IF WE WERE OLDER: POST-LINEAR GROWTH PHASE CHICKS AS INDICATORS OF SEASONAL CHANGES IN PROVISIONING IN BLACK GUILLEMOTS.

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Using seabirds to indicate changes in the marine environment is critical in the Arctic where monitoring is logistically difficult, costly and not carried out. Determining variation in the quality of the foraging environment using alterations in the Linear Growth Phase (LGP) of the mass of alcid chicks has been one of the more specific metrics. Later stages of chick growth, however, are often highly variable and, thus, are not considered reliable metrics. Daily measurements of all Black Guillemot (*Cepphus grylle*) chicks at the Cooper Island colony were conducted during chick rearing in 2005 and 2006. Using a seasonal daily mean of LGP chicks to compare levels of provisioning between years may be problematic due to the disproportionate effects of a few high or low level days on seasonal means. The seasonal daily mean mass gain of LGP chicks was significantly different in 2005 (11.1 ± 0.4 g/d) relative to 2006 (15.1 ± 0.3 g/d); however, the exclusion of 3 days from the breeding season of 2005 made the seasonal means identical (15.1 ± 0.4 g/d). We developed a method to analyze daily anomalies from expected growth using LGP and Post-Linear Growth Phase (PLGP) chicks. Mean daily PLGP anomaly generated values which are highly correlated with daily LGP anomalies ($r^2=0.904$, $n=18$, $p<0.0001$). The linear nature of the relationship allowed PLGP anomalies to be converted to the same scale as LGP anomalies. Therefore, comparison was possible within and between breeding seasons to measure seasonal alterations in the level of provisioning during parts of the breeding season which were previously indicated by only a few of the late breeders. This technique has exciting possible applications for monitoring using a wide spectrum of future and historic chick mass data.

BOTH SIDES NOW: INTERNAL METABOLISM AND EXTERNAL DAYLIGHT REGIMES EFFECT CHICK MASS OF THE BLACK GUILLEMOT (*Cepphus grylle*).

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To use chick mass as an indicator of prey availabilities, it is vital to understand the complex factors at play which influence the mass of a chick at any given date or time of day. In 2006, we performed 197 h of feeding watches, where 4-12 nests were observed for 1.5-2.5 h blocks as well as two continuous 24 h watches. We also measured the mass of 382 chicks before and after a feeding watch to determine mass change during the watch period. The rate of mass loss (g/h) was significantly but weakly correlated with the initial mass of the chick ($r^2=0.056$, $n=108$, $p<0.02$). The weakness of the correlation and the absence of a significant relationship with the mass-corrected rate of mass loss are explained by the existence of non-linear age-specific rates of mass loss. Three age classes (Early: 10-15 d; Middle: 16-25 d; Late: 26-35 d) showed significantly different mean rates of mass loss (4.0 ± 0.8 g/h, 6.6 ± 0.9 g/h, 3.6 ± 0.6 g/h) when chicks were known to be unfed. These rates correspond to different daily energy expenditures (DEE) needed for the maintenance of different age chicks. Subsetting the data into before and after a noted colony-wide decline in provisioning rates revealed significant rate changes for Early (1.1 ± 0.4 g/d) and Middle chicks (3.6 ± 1.0 g/d); however, the inter-age-class pattern remained. Dry bulb temperature did not correlate significantly with rate of mass loss in unfed chicks, which indicates unbrooded Black Guillemot chicks in the arctic are likely in their Thermoneutral Zone (TNZ). Chick feeding rate was continuous throughout the day during the early chick rearing season when there was 24 h of daylight. Chick feeding rates later in the season, with 6 h less daylight, showed a pronounced Gaussian pattern. These results suggest that chick age and varying provisioning rates throughout the day resulted in daily variation in chick mass, where nest temperature did not. This is important when using daily chick mass measurements as indicators of prey availability in the marine environment.

CALIFORNIA BROWN PELICAN NESTING PARAMETERS AND PREY DISTRIBUTIONS, 1986-2005.

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Seabird nesting productivity is strongly tied to local food availability, but quantitative studies are often difficult to perform. For the California brown pelican, food studies in the late 1970s and early 1980s identified local availability of Northern anchovy (*Engraulis mordax*) as the most important determinant of reproductive success of brown pelicans nesting on West Anacapa Island. These studies were performed during a period of very low Pacific sardine (*Sardinops sagax*) population levels in the California Current system; it was believed that sardines might represent a significant food source if locally available. The sardine population has since recovered, while anchovy abundances have been in general decline since the mid-1980s. This project evaluates relationships among brown pelicans and coastal pelagic prey (anchovy and sardine) over a 20-year period. We describe trends in pelican reproduction at West Anacapa Island, California with respect to interannual and seasonal trends in distribution and abundance at two scales of prey availability.

FUN WITH SEABIRD DEMOGRAPHIC MODELS: EVEN MARBLED MURRELETS CAN BE INTERESTING

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When a population is monitored over a period of time it typically exhibits trends—sometimes it increases, at other times it declines. If it declines substantially, concerns arise about the possible need for intervention. Much attention is given to the issue of statistical significance. We want to be sure of detecting a negative trend in time to take conservation actions that could slow or reverse the trend. Statistical power analysis is a helpful tool in designing sampling protocols with known probabilities of detecting trends. However, once a statistically significant trend is detected (a downward one in particular), how do we decide whether it is a problem? What is the biological (as opposed to statistical) significance of the trend? Is the population on a trajectory that would be unlikely to occur as an outcome of natural fluctuations in fecundity and survival? What we want is a biologically defensible action threshold—a trend of a certain magnitude and duration that, once detected, provides a consensus basis for conservation action. I approached this problem using a matrix model that allows birth and death rates to vary stochastically. In the stochastic model, trends arise from the chance juxtaposition in time of high and low levels of productivity and survival. I applied the model to Marbled Murrelets using the best available estimates of interannual variability in fecundity and survival. The analysis suggests that changes exceeding +100% or -60% can arise by chance over periods of 10–30 years. To assess its biological significance, an observed trend is compared with the expected distribution of trends in a manner analogous to the conventional use of probability in statistics.

COMPARISON OF AERIAL AND AT-SEA SURVEY METHODS FOR ESTIMATING ABUNDANCE AND DISTRIBUTION OF MARBLED MURRELETS AND OTHER MARINE BIRDS

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At-sea (boat-based) surveys for marine birds have an advantage over aerial surveys in that observers have more time to identify animals and concurrent data can be collected on biological and physical characteristics of the ocean. Aerial surveys, however, are an effective tool for surveying marine birds over large areas in a short amount of time. Relatively little information is available on the accuracy of density estimates from aerial surveys, however, or on potential differences between aerial and boat-based survey density estimates. We conducted simultaneous aerial and boat-based surveys for marine

birds, with a special emphasis on the Marbled Murrelet (*Brachyramphus marmoratus*), a small, threatened seabird. We surveyed 45 8-km transects off Santa Cruz, California, over six days during the winter of 2005/2006. We found that density estimates for Western/Clark's Grebes (*Aechmophorus occidentalis/clarkii*) and for all loon species (*Gavia* spp.) combined were significantly greater based on aerial surveys than on boat-based surveys. However, boat-based surveyors identified significantly more individual species per transect than aerial surveyors. Density estimates for Marbled Murrelets from the two platforms were nearly identical, and there was no statistical difference between density estimates by platform for all birds combined or for other individual species. These results indicate that aerial surveys can provide accurate density estimates for Marbled Murrelets, and that for most species, density estimates from aerial surveys and boat-based surveys are comparable. For some species, however, boat avoidance may lead to biased density estimates from boat-based surveys.

AT-SEA TIME BUDGETS FOR GENTOO PENGUINS DURING WINTER.

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Long-term investigations of gentoo penguin (*Pygoscelis papua*) populations in the South Shetland Islands, Antarctica have focused on the summer breeding season. However, winter periods have been increasingly suggested as important bottlenecks for penguin populations. To study the winter behaviors and patterns of habitat use by gentoo penguins, archival temperature tags were used to measure the amount of time spent at sea during winter months. Temperature recording tags were attached to adult gentoo penguins after molting in late February 2005 and 2006 at Admiralty Bay, King George Island and Cape Shirreff, Livingston Island, both in the South Shetland Islands archipelago. A calibration study conducted in February 2006 confirmed that the temperature tags can be used to measure the amount of time that the birds spend in the water. Eight tags bearing over-winter data have been recovered from 4 penguins in November 2005 and from 4 penguins in November 2006. Preliminary analyses of data from 2005 suggest that trips to sea occurred diurnally around local noon, but the diel pattern weakened or disappeared when air temperatures dropped below -5°C, particularly during mid-winter months when daylight hours were most reduced. On a weekly basis, however, the average time spent at sea was variable (mean = 63.5 hr, sd=14.3 hrs) and showed neither an over-winter trend nor a correlation with the changes in total daylight during winter months. These results suggest that gentoo penguins may adopt environmentally-dependent at-sea time budgets to meet energetic demands during winter.

FORAGING STRATEGIES AND YOLK CAROTENOID DEPOSITION IN A COMMUNITY OF MARINE BIRDS

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For birds, meeting the nutritional demands of egg production may require the adoption of specific foraging strategies. Female birds deposit carotenoids and other antioxidants into egg yolk, and this maternal effect is critical to the development, health, and survival of offspring. Unable to synthesize carotenoids *de novo*, vertebrates must obtain them in their diet, and results of several experimental studies suggest that carotenoid availability limits avian egg production capacity. We measured carotenoid concentrations and stable isotope ratios of carbon and nitrogen in egg yolk and potential prey items to investigate foraging strategies associated with egg production in 5 species of alcids at Triangle Island, British Columbia, in 2002-2006. Alcid species that foraged at lower trophic levels and in more offshore or pelagic environments produced egg yolks higher in carotenoid concentrations, a pattern that also occurred within one species, the Rhinoceros Auklet (*Cerorhinca monocerata*). Yolk

colour was also strongly indicative of trophic level. In addition, yolk carotenoid concentrations varied among years in both Cassin's Auklets (*Ptychoramphus aleuticus*) and Rhinoceros Auklets; in the latter, concentrations were lower in years of later and less successful breeding. Results of our study offer insight into the foraging strategies of marine birds during the period of egg formation, a topic that remains largely unexplored.

USE OF DISTINCT MARINE HABITATS BY THREATENED PINK-FOOTED SHEARWATERS: IMPLICATIONS FOR CONSERVATION

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The Pink-footed Shearwater *Puffinus creatopus*, a Chilean endemic, has IUCN Vulnerable status due to its restricted breeding range and possible declining populations. Breeding populations in the Juan Fernández Islands are threatened by introduced mammals, including predation and competition for burrows. Additionally, there is concern about possible interactions with commercial fisheries (i.e., bycatch, prey competition) at sea. To determine foraging locations and habitat use patterns, we deployed satellite transmitters on breeding shearwaters during both chick-rearing (2002-2005) and post-breeding migration (2006). When provisioning chicks, tracked shearwaters primarily traveled east to the Chilean continental shelf but also exploited oceanic waters. Oceanographic characteristics differed between these two trip destinations, with shelf/shelf-break areas characterized by shallower, colder and more productive waters. Habitat use patterns varied interannually, with pelagic waters significantly more important in 2005 than in previous years. The Talcahuano region, a foraging hotspot for breeding birds from the Juan Fernández Islands, was also an important feeding location for shearwaters breeding on Isla Mocha. This hotspot falls within the region with the most commercial fishing activity in Chilean waters. During migration, tracked shearwaters traveled northward, primarily along the shelf/shelf-break, with all birds heavily utilizing these highly productive waters off central Peru. One bird was tracked as far north as the Bahía Magdalena region of Mexico where it resided for three weeks in shelf/shelf-break waters. Our results suggest that shelf/shelf-break waters are fundamentally important to this species and coincide with areas of high fishing and shipping activity.

FINDING ENDANGERED SEABIRDS ON KAUA'I, HAWAI'I: AUDITORY SURVEY METHODOLOGY AND SPATIAL ANALYSES

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Newell's Shearwaters (*Puffinus auricularis newelli*) and Hawaiian Petrels (*Pterodroma sandwichensis*) are endemic to Hawaii, and State and Federally listed as threatened and endangered species, respectively. The Band-rumped Storm-petrel (*Oceanodroma castro*) is State listed as endangered and a candidate for listing under the Federal Endangered Species Act. These three species breed within the remote interior and along the west coast of Kaua'i, in rugged terrain that is often very steep and difficult to access, making estimations of colony distribution difficult and approximate only. All three species would benefit from better estimates of their distribution on Kaua'i, to address goals of a) monitoring overall population health, and b) identifying and prioritizing accessible colonies where on-ground management activities are needed. Auditory surveys or point counts are used to achieve a variety of aims for ornithology, with the listener relying on acoustic and visual cues to identify the presence of a species. On Kaua'i, auditory surveys are one of the primary tools we use to document 'hotspots' of endangered seabird activity in remote areas, including major flyways and colonies. Here we outline 1) the field methodology for a customized point count to document calling activity of endangered seabirds on Kaua'i, and 2) examples of these data expressed spatially for guiding future management efforts with these species.

CONSERVATION STATUS OF THE HAWAIIAN PETREL *PTERODROMA SANDWICHENSIS* ON KAUA'I, HAWAII.

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The Hawaiian Petrel (*Pterodroma sandwichensis*) is State and Federally listed as endangered, with the breeding range restricted to the main Hawaiian Islands. Indirect evidence of Hawaiian Petrels breeding on Kaua'i is relatively well documented, with adults seen and heard flying inland at dusk, and fledglings rescued from the ground after falling victim to artificial light attraction. Despite the petrels' documented presence on Kauai, their exact breeding locations within the mountainous interior of the island remain elusive, with inland encounters consisting only of occasional calls heard from flying birds. Identifying breeding sites is a crucial first step for effective management of these birds, including implementing on-ground activities to protect colonies. Recently, burrows of breeding Hawaiian Petrel were discovered in the remote Limahuli valley, the first thought to be documented on Kaua'i. The habitat type in which they were encountered differs in elevation and vegetation type from other known breeding sites in Hawaii. These differences are especially marked in comparison with the high elevation population at the summit of Haleakala on Maui, the only site where this species has been studied and monitored in any depth. This contrast illustrates the extreme variability of this species' habitat among islands, and highlights the need for island-specific conservation measures to protect the Hawaiian Petrel. Here we document 1) Hawaiian petrel encounters on Kauai to date, 2) a brief description of the habitat from a recent discovery of a colony, and 3) an update on the conservation status of the Hawaiian Petrel on Kauai, including known threats and critical management actions.

IDENTIFICATION OF IMMATURE SALVIN'S, CHATHAM, AND BULLER'S MOLLYMAWKS (ALBATROSSES)

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Perhaps the most fundamental tenet of field biology is being able to identify the species one is studying. For on-land projects this usually isn't too difficult, but for at-sea studies identification criteria are still evolving, such as for several taxa of albatrosses, gadfly petrels, and storm-petrels. The immature stages of various albatross taxa are poorly known because such birds do not usually visit the breeding grounds, where most studies are conducted. Here I review characters that can be used to identify and age first-year and second-year Salvin's (*Thalassarche [cauta] salvini*), Chatham (*T. [c.] eremita*), and Buller's (*T. bulleri*) Mollymawks, based on field observations since 1992 in the Humboldt Current, off Chile. Molt patterns, primary wear, underwing pattern, and bill pattern are the main characters helpful for ageing these taxa. Buller's Mollymawk attains adult-like bill pattern more quickly than does the larger Salvin's. Provisional data are provided on the relative abundance off Chile of northern- and southern-breeding populations of Buller's Albatross.

TEN YEARS OF DISTANCE SAMPLING LINE TRANSECTS FOR SEABIRDS WORLDWIDE: EXPERIENCES WITH THE RESEARCH COMMUNITY, AND FROM OPPORTUNISTIC BIRD SURVEYS, DETECTABILITY PROBLEMS AND GIS DATABASES

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The statistical survey literature promotes since over two decades that it is naïve to assume that all birds could be detected along the transect and in the ocean. It took a long time to overcome the resistance to correct bird sightings for detectability biases, and using corrected raw (strip-transect) data for management actions (*sensu* Anderson et al. 2003). Here I show experiences from over 10 published studies surveying, analyzing and publishing seabird data for distributions, densities, populations and

trends. Applications presented cover seabird monitoring and research in the Atlantic and Pacific, and deal as well with general and abundant species (e.g. gulls, fulmars and auks) but also with species of high conservation concern (Razorbill *Alca torda*, Marbled and Kittlitz's Murrelet *Brachyramphus marmoratus brevirostris*, Short-tailed Albatross *Phoebastria albatrus*). Further, I show the relevance of Metadata to understand how to interpret and analyze such data efficiently. Sound seabird abundances with statistical confidences are the key for good science, for seabird management, for sustainable oceans and for GIS mapping and modeling. Alternatives to DISTANCE Sampling are presented, modeling applications are shown how to overcome detectability problems in seabird data. Finally, a call is made towards a unified global seabird survey protocol, allowing for a biologically valid database merging and synthesis of seabirds at sea beyond administrative borders and incompatible protocols covering entire flyways and oceans.

GLM, GLMM, RSF, ENFA, MAXENT, ANN, MARS, CART, BOOSTING (TREENET) AND BAGGING (RANDOMFOREST): STATE OF THE ART FOR DATA MINING AND PREDICTIVE BLACKBOX MODELING OF 'PRESENCE ONLY' DATA IN A GIS FRAMEWORK.

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Raw data are limited in their direct use for seabird management. Modeling allows to overcome many of these problems and shortcomings. Together with free online ecosystem data (e.g. OBIS-Seamap, ArcOD, COADS), the development of R software as well as progress in machine learning algorithms allows for an efficient sustainable seabird and ocean management. A new philosophy is formed resulting into Ocean Informatics and Adaptive Management based on modeling free public online digital data. Here I focus on methods that allow to support these concepts, and that are relevant for the species biology. I will show examples from seabirds of the world using the latest spatial modeling algorithms, and then briefly explain how they evolved and get applied. Presented examples deal mostly with Albatross species data (geo-referenced sightings and data loggers). Findings show that the focus for reliably modeling of telemetry data needs to be on predictions rather than on traditional inference, and on extensive accuracy assessments based on a variety of available, alternative high quality data sets world-wide. The large-scale focus for such data matters due to the wide movements these animals make. An outlook is given where the analysis of telemetry is going, and what (certified) software tools we already have, and what we still require.

NEW CONTRIBUTIONS FROM SEASCAPE ECOLOGY: SCALE EFFECTS IN SEABIRD DISTRIBUTIONS USING THE PIROP DATABASE IN THE NORTH WEST ATLANTIC

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The investigations of scale are of practical importance for describing patch size of predator and prey, determining the appropriate scale of study and correcting survey transects. We conducted this study in order to explore a substantially wider diversity of spatial scales than has previously been attempted in the pelagic bird literature. We use the PIROP (Programme intégré pour le recherche des oiseaux pélagiques) data set to investigate relevant large-scale issues for seabirds in the Northwestern Atlantic. We analyzed autocorrelation within selected winter and summer transects, and for 1 degree analysis units ('bins') for data collected June-August 1966-1992 covering the entire study area. We also investigated effects of the analysis unit on counting results and on the links between seabirds and their environment (depth, sea surface salinity and temperature). We selected scales of 1, 2, 5 and 10 degree analysis units, referenced by latitude and longitude; an ecological mapping scale ('Banks' not deeper than 200 m) and a political scale (management convention zones of the North Atlantic Fisheries Organization, NAFO) were also included. Using 'binning' of various scales, our results show that the CV for seabird abundances varies among aggregation scales, and that seabird associations with their

environment show scale effects. Autocorrelation of analysis units indicated some distinct larger scale patch sizes for particular seabird species during the breeding season. We propose a new philosophy dealing with this important subject relevant for most spatial survey data and GIS overlays, for their study, and for the generalizations of findings.

SEABIRDS AND MARINE RESOURCES OF THE VOSTOCHNYA WATERSHED ZAKAZNIK, SAKHALIN ISLAND, IN THE WESTERN SEA OF OKHOTSK: INVENTORIZING THE LAST REMAINING INTACT MARINE WILDERNESS AREAS

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The watershed of the Vostochnya Zakaznik (estuaries of the Verengi and Prushprush rivers) is classified as one of the last intact wilderness areas in the Pacific Rim. However, quantitative biodiversity assessments for this region are just beginning, and the status of this region is not well known in the international community. Based on our fieldwork during August 2006 and other information, an overview is presented for this region from boat-based DISTANCE Sampling line transects. Quantitative species lists are also presented for ‘bazaars’ (seabird colonies on rocks and coastal cliffs), for whales, for sea mammal rookeries and herds, and for related ecosystems, e.g. coastal old-growth forests. Research data are described with FGDC NBII Metadata so that they can enter the global public online data heritage in a digital format according to Global Biodiversity Information Facility (www.gbif.org) standards. Results presented here show for the first time quantitative baseline estimates capturing minimum estimates. Overall, the region still appears to be almost untouched with a more or less intact salmon run, food chain and fascinating ecosystem. It represents a global experiment and natural control for ‘untouched’ zones. It should be noted that this region appears to be a fragile ‘island’ constantly threatened by human encroachment, e.g. poaching, fishing and pollution (oil/gas). Rather than looking at individual impacts, considering the cumulative impacts will show the true status of this region. An outlook is given how this fascinating region fits into the Russian, Pacific and global conservation context, and how a successful management could look like.

ESTIMATING SURVIVAL FOR SEABIRDS THAT SKIP BREEDING: THE CASE OF THE WANDERING ALBATROSS.

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Many larger seabirds do not breed every year, even though they are generally considered to be annual breeders. This complicates survival estimation if non-breeding birds do not attend the breeding colony and are not available for capture. This lack of availability for capture at some sampling occasions is known as temporary emigration. Classic mark-recapture methods are not robust to the assumptions this violates. Multi-state mark-recapture methods can explicitly model the unobservable states caused by temporary emigration. Including unobservable states adds parameters without adding information so requires some kind of additional constraints to enable all parameters to be estimated. Such models can be a rich source of biological hypotheses. We use models with unobservable non-breeding states to investigate hypotheses about survival and breeding probabilities for the Wandering Albatross (*Diomedea exulans*) on Bird Island, South Georgia. We include four states: 1) successful breeders, 2) unsuccessful breeders, 3) non-breeders whose previous breeding attempt was successful, and 4) non-breeders whose previous breeding attempt failed. Breeding probabilities differ more among states than do survival rates. Both breeding probabilities and survival rates are highly variable over time. These are

the first survival estimates for seabirds that account for unobservability during years when breeding is skipped.

SEABIRD ATTRACTION TO SURVEY VESSELS: STEPS TOWARDS THE DEVELOPMENT OF STANDARDIZED CORRECTION FACTORS.

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The tendency of many seabird species to attend and follow survey vessels can bias the study of their at-sea distributions and the structure of the marine avifauna. The tendency of seabirds to approach a vessel from a distance greater than the width of the survey strip inflates their apparent densities. Individual birds of some species will follow the survey vessels for hours, further biasing their apparent densities. In this presentation, I discuss three methodological approaches to quantifying the response of seabirds to vessels: focal observations of individual ship followers, paired bow / stern point counts, and strip transects of varying width. Field observations using these methods indicate there are species-specific differences in the degree of vessel attraction; while some species (e.g., albatrosses) disproportionately engage in ship-following, others (e.g., prions) are apparently not attracted to survey vessels. Quantifying these species-specific responses to vessels under varying survey and weather conditions has important methodological implications for the development of standardized metrics of seabird abundance and community structure. To this end, several correction factors have been developed to mitigate the biases introduced by the tendency of ship-followers to attend and follow survey vessels.

MAPPING FORAGING AREAS OF SEABIRDS AT RISK FROM LONGLINE FISHING: A TOOL FOR ASSESSING INTERNATIONAL CONSERVATION RESPONSIBILITIES.

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More than 22 species of globally threatened petrels and albatrosses are killed by longline fishing operations. Seabird bycatch can be greatly reduced through the use of cost-effective mitigation measures. Additionally, as the conservation status of many tubenose seabirds continues to deteriorate, precautionary fishing ground closures could become a widespread management method. Yet, these management approaches require critical knowledge about the spatial and temporal overlap of seabird marine ranges with different national and fishery jurisdictions, and about the extent and location of high-use foraging grounds. This geo-spatial information will help identify conservation responsibilities and target bycatch mitigation efforts in time and space. BirdLife International, in conjunction with researchers around the world, is compiling a database of seabird distribution data to identify the most important foraging areas for threatened species at regional and global scales. Here we describe the results of a pilot study focusing on several species for which we have good knowledge of key foraging areas. To illustrate how this integrated perspective can be used to guide conservation efforts, we relate the seabird distribution data to the extent of Exclusive Economic Zones and Regional Fishery Management Organizations. Electronic copies of the report are available online at: <http://www.birdlife.org/action/science/species/seabirds/tracking.html>

HOW AND WHY DO RHINOCEROS AUKLETS SWITCH THEIR DIET TO ANCHOVY?

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Changes of the diet for chicks during middle of the chick-rearing period have been reported in variety of seabirds. Major cause of this diet switching would be seasonality of prey availability. Rhinoceros auklets *Cerorhinca monocerata*, breeding at Teuri Island, Hokkaido, switch their diet from juvenile arabesque greenling *Pleurogrammus azonus* and sand lance *Ammodytes personatus* to anchovy *Engraulis japonicus* within a week at the middle of chick-rearing period. Anchovy is warm-water related species in this area and seasonally expands its distribution to the north because of the extension of the Tsushima Warm Current. To understand the behavioral mechanism and ecological consequences of the prey switching in Rhinoceros Auklets, diving behavior and bill-loads of chick-rearing parents were monitored with small depth-temperature data-loggers and infrared video cameras. Approximate foraging area was estimated using SST. Some parents used northern sea area before 11 June and changed their foraging area to the south in 11-13 June, while others consistently used southern area. Most birds switched diet to anchovy on around 17 June. Estimated foraging efficiency (mass of bill-load per time of the last dive bout) was greater for birds bringing anchovies than others. Consequently, daily mass growth of chick body was greater when they were fed with anchovies. We conclude that auklets changed their foraging area to switch their diet to anchovy, easy to forage and have positive effect on chick growth.

MOVING AND REARING ALBATROSS CHICKS TO SUPPORT SHORT-TAILED ALBATROSS RECOVERY: LESSONS LEARNED

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The pilot translocation and rearing project reported here is a preliminary step to conducting an operational translocation of Federally endangered short-tailed albatross (*Phoebastria albatrus*) chicks. The Short-tailed Albatross Recovery Team has indicated that additional breeding colonies of short-tailed albatross must be established in order to achieve recovery of this species. By translocating short-tailed albatross chicks to a new safe colony site, we hope to 'jump-start' the process of new colony formation, thereby expediting the species' recovery. This project served as a first practice run, aimed at finding out: "Can we move and rear albatross chicks without killing them?" In early March of 2006, ten Laysan albatross (*Phoebastria immutabilis*) post-guard stage chicks, approximately one month of age, were captured at Sand Island, Midway Atoll National Wildlife Refuge (NWR) and moved to Kilauea Point NWR, Kauai, Hawaii, where we attempted to rear them to fledging (in late June/early July). Of these ten chicks, five survived to fledging and four fledged successfully. Sources of mortality included exposure and bacterial infections. Much valuable information was gained concerning chick nutrition and handling procedures. This information will be applied to future efforts. In 2007, we plan to translocate and rear black-footed albatross chicks at an artificial colony site that has been set up in the Mukojima Island group, and if all goes well, we anticipate an operational translocation of short-tailed albatross chicks to this site in 2008.

CLIMATE, FISH AND BIRD ABUNDANCE CORRELATES AT MULTIPLE TEMPORAL SCALES.

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We examined relationships between climate, fish and seabird abundance off the coast of Peru. We examined the hypothesis that changes in fish and seabird abundance in the Peruvian Upwelling System are indirectly driven by climate variability at multiple time scales. We tested this hypothesis by analyzing time series data on fish (anchovy *Engraulis ringens*; sardine, *Sardinops sagax*) and seabirds (cormorant, *Phalacrocorax bougainvillii*; booby, *Sula variegata*; pelican, *Pelecanus thagus*) off the coast of Peru (from 6° S to 14° S) in relation to oceanographic variables (wind stress, surface temperature and thermocline depth) and atmospheric indices (Southern Oscillation, North Pacific Decadal Oscillation) from 1950-2005. We explored the use of the Peruvian Oscillation Index (doi:10.1029/2003GL017345) for analysis; this index captures both interannual variability related to El Niño-Southern Oscillation and interdecadal variability related to the North Pacific Decadal Oscillation. This hypothesis is important because much of the primary literature attributes changes in fish biomass and seabird numbers to climate variability at interannual (ENSO) and interdecadal scales (PDO). We tested for co-variation in climate, fish and seabird time series, and examined lags or leads that could be used to predict one from the other.

AT-SEA DISTRIBUTIONS OF MARINE BIRDS AROUND THE PRIBILOF ISLANDS: A MULTI-YEAR COMPARISON OF TEMPORAL AND SPATIAL PATTERNS.

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We examined trends in abundance and distribution of 14 species of marine birds around the Pribilof Islands, southeastern Bering Sea, from 1977 to 2004. We contrasted patterns among piscivores and planktivores and related these to known and hypothesized changes in the abundance and distribution of prey in the vicinity of the islands. Planktivorous and piscivorous species of marine birds showed different patterns of abundance over time. Planktivores showed a 6x increase from the 1970s to very high numbers in the 1980s, followed by a rapid decline to about 10% of the numbers present in the 1980s that then persisted through the 1990s and 2000s. The abundance of all piscivores was high in the 1970s and 1980s, and then declined through the 1990s and 2000s. In 1999 and 2004, the total number of all seabirds at sea around the Pribilof Islands was far below the numbers seen at any other survey period. We hypothesize that these changes in the abundances and types of seabirds present through time reflect major changes in the structure of the marine ecosystem of the eastern Bering Sea shelf. We suggest that changes in pathways of energy flow may be responsible for these shifts, though the possibility that there has been a reduction in productivity cannot be discounted given the sparsity of available data.

RESPONSE OF PLANKTIVOROUS DOVEKIE (*ALLE ALLE*) TO CHANGES OF OCEANOGRAPHIC CONDITIONS IN FEEDING AREA.

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Adult Dovekie (*Alle alle*) breeding in Hornsund (Spitsbergen) feeds the chicks almost exclusively with high energetic Arctic zooplankton items associated with cold polar waters. In years with a stronger influx of warm Atlantic waters (positive NAO index) in their traditional feeding grounds, they may be forced to forage on less profitable Atlantic zooplankters associated with those water masses. This study compares the Dovekie chick diet in two seasons with different distributions of water masses in the vicinity of Hornsund fjord – cold 2004 (cold Arctic waters were found in large quantities in this

area) and warm 2003 (with the considerable presence of warm Atlantic waters). Food samples were taken from gular pouch of adult birds transporting food for chicks. Parents delivered to their chicks less food of lower energetic value per load in the warm season comparing to the cold one. It suggests that Dovekie foraged then in suboptimal feeding area. However, time budget and foraging strategy of adult breeding Dovekies were flexible, and at least within the range of the NAO effects under this study, the parents were able to compensate worse food condition in warm year by bringing an additional daily meal so the chicks received the same amount of energy (by mass and energy) like in cold year.

DIFFERENT RESPONSE OF DOVEKIE (*ALLE ALLE*) MALES AND FEMALES TO VARIABLE PREY AVAILABILITY ON FEEDING GROUND

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Differences in quantity and quantity of food loads brought to chicks by males and female of Dovekie were examined in a breeding colony on South Spitsbergen in two seasons with different distributions of cold (Arctic) and warm (Atlantic) water masses in the vicinity of colony. The most favorable Dovekie food is associated with cold waters and there are evidences that oceanographic variability on their feeding ground may affect them. Adult birds with their gular pouch filled with food were caught in mist-nets and loads were taken. Each bird was sexed by molecular methods. In season with high influx of Atlantic water masses females brought significantly more food per single load than males in terms of wet weight (30% on average), number of prey items (46% on average) and total energy contents (39% on average). However, these sex differences were not found in season with large cold water distribution. Nevertheless of water masses variation males brought relatively more proportion of cold water zooplankton than females did. This indicates that males are more selective than females and irrespective of oceanographic conditions on feeding ground focus on the most preferred food items. This study delivers some answers on still remaining open question how the different sexes may respond to changes in availability of prey caused by oceanographic variability in their feeding ground. This also emphasizes the importance of investigating differences between the sexes in what appear to be sexually monomorphic species.

HABITAT CONNECTIVITY; SEABIRD EFFECTS ON INTERTIDAL COMMUNITIES ON ISLANDS IN BAHÍA DE LOS ANGELES, MEXICO.

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While there have been numerous elegant studies demonstrating the profound effects of ornithogenic (bird-derived) nutrients on terrestrial ecosystems in Bahía de los Angeles, Mexico, few of these have explored the interactive effects of seabirds, terrestrial geomorphology, and nearshore marine habitats. In this study, we examined how ornithogenic (bird-derived) nutrients affect benthic intertidal ecosystems at two tidal elevations. High guano input to upper elevation intertidal areas increased biodiversity, tended to increase overall abundances, and had other taxa-specific effects. These effects were not evident at lower tidal elevations. These findings suggest that seabirds are important mediators of intertidal community structure, through bottom-up mechanisms, and have important consequences for ecology and conservation.

SUGGESTED EXPERIMENTAL DESIGNS FOR ATTACHED-GEAR STUDIES OF SEABIRD BEHAVIOR AND MOVEMENT AT SEA.

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Studies employing attached instruments to measure seabird behavior require proper controls, just like any other experiments addressing questions about animal behavior. Nevertheless, many past studies had no controls to quantify the effect of instruments. Since any attached gear will act as a handicap that reduces flight and diving performance, 'gear effect' must be quantified and data corrected before realistic conclusions about movement behavior can be derived. Here I review some basic requirements for experimental rigor in such studies. Formulating a clear question is essential. An experimental design to answer that question will then involve the proper controls for disturbance due to capture and handling, effect on flight and diving performance, health and survival effects (most acute for implanted gear). For breeding seabirds, this involves comparisons, at a colony site, of handicapped (gear attached) marked birds with marked captured individuals with no gear, with age, sex and breeding status as factors. The gear effect is the performance difference between adequate samples of handicapped and non-handicapped birds. Migration studies of non-breeding birds offer greater challenge to researchers, because of the longer duration of stress, and have more crucial requirements for controls. Such studies should be preceded by a breeding colony-based feasibility trial using dummy attachments to measure gear effects. Only after gear effects have been demonstrated to be small should the study proceed with careful controls involving measurements of free-living birds in the same population. Gear effects are expected to be most important for diving seabirds (alcids) and long distance migrants.

FORAGING DYNAMICS OF LITTLE AUKS (*ALLE ALLE*) IN THE GREENLAND SEA

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The Greenland Sea is characterized by several surface currents with different physical and biological properties due to their divergent origins. The Sorkapp current flows north along the west side of Spitsbergen, Norway and originates in the Northern Barents Sea. This northerly flowing current is relatively cold due to the entrainment of Arctic water at its northern origins. The warmer West Spitsbergen current brings Atlantic water from the south into the High Arctic. The coldest surface current flows south along the west coast of Greenland. In 2005, we conducted net tows and measured the physical properties of the different water masses while on board the sailboats *R/V Oceania* and *R/V Vagabond*. We hypothesized that the different water masses would have different zooplankton species and that little auks would forage where the largest, most energy rich prey are. Little Auk breeding colonies border the West and East sides of the Greenland Sea. We surveyed the at-sea distribution of Little Auks foraging in the Greenland Sea close to the colonies at Hornsund Fjord, Spitsbergen, Norway and close to Kap Höegh, Greenland. We collected food loads from adults to determine the zooplankton species that were being preyed on. We found that little auks foraging near Greenland were uniformly distributed across the cold and energy-rich water. Birds near Spitsbergen had a disjunct distribution with higher densities of birds feeding in the Sorkapp current and few birds in the Atlantic influenced water. Little Auks may be a good indicator of oceanographic conditions in the Greenland Sea.

TRACKING ALBATROSS AND TRASH ACROSS BORDERS: A TOOL FOR INTEGRATED OCEAN, COASTAL, AND WATERSHED CONSERVATION

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The far-ranging, long-lived Black-footed Albatross (*Phoebastria nigripes*) can provide useful information about human-related impacts to marine ecosystems. Albatross are surface feeders that feed on fish and squid on the ocean surface. They also ingest floating plastic debris which adults then feed to their chicks with potentially detrimental effects on their growth, contaminant loads, and survival. A satellite telemetry study to investigate movements of albatross, habitat use, and overlap with marine debris during 2004 and 2005 is being used to increase public awareness of the critical need for plastic pollution prevention. The “Eastern Garbage Patch” is a persistent oceanographic feature that accumulates plastic debris from both sides of the North Pacific in alarming densities. Results of our GIS mapping analysis indicated 13 of the 18 tagged birds ventured into this region where they spent on average 26% of their time during their post-breeding movements (July-October). Through diverse local and national outreach collaborations, including teacher workshops, development of classroom activities, production of posters and stickers, and the direct engagement of the public through lectures and beach clean-ups, we have used this charismatic marine predator as a tool to link the daily actions of people with conservation problems across borders and oceans.

RESTORING SEABIRD HABITAT ON LEHUA ISLAND BY REMOVING RABBITS

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Non-native mammals introduced to islands are the leading cause of population declines and colony extirpations for seabirds. Predators such as cats (*Felis catus*) and rats (*Rattus sp.*) are often the most damaging. However, introduced herbivores on islands, such as rabbits (*Oryctolagus cuniculus*) can impact seabirds in three main ways: 1) decrease nesting habitat quality by consuming vegetation used for nesting and reducing soil stability by reducing vegetation cover; 2) direct competition for nesting sites with burrow nesting species and eviction of bird's eggs; and 3) sustaining increased predator populations (such as cats and rats) and thus predation rate on seabirds by providing an alternate prey source. Fortunately, techniques and expertise exist to remove rabbits from islands and over the past 100 years more than 40 eradications have occurred on islands ranging from 1 to 1,400 hectares (2.5 to 3,500 acres). Lehua Island, 120 hectares, is among the most important seabird colonies in the main Hawaiian Islands with 50,000 individuals and eight to twelve breeding species. An effort to remove rabbits from Lehua was initiated in 2005 using hunting, dogs and trapping. The field work was completed in 70 days on the island and was estimated to cost a total of \$130,000 USD. The expected outcomes of this work are an increase in seabird numbers and recovery of sensitive plant populations. Monitoring to measure the effects of rabbit removal and a rat (*Rattus rattus*) eradication will be carried out over the ensuing several years.

USING CONDUCTIVITY LOGGERS AND RADIO TELEMETRY TO DOCUMENT AT-SEA BEHAVIORS AND LOCATIONS OF SURFACE-FEEDING SEABIRDS.

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Understanding the behavior and location of foraging seabirds is an active and rapidly expanding frontier of marine bird research. We studied the at-sea activities of surface-feeding Black-legged Kittiwakes (*Rissa tridactyla*) in Chiniak Bay, Alaska, from 2001-2005 by deploying tail-mounted saltwater-detecting data loggers (6g, Advanced Telemetry Systems, Isanti, MN) and VHF transmitters on active breeders. Conductivity loggers recorded the time (1/4 s accuracy) and conductivity associated with each transition between air and water (up to 11,000 transitions) of two stainless steel contacts located on a trailing, flexible 20cm-long “antenna.” We used automated, radio receiving stations to document the presence of radio-tagged kittiwakes at their nest sites and within several overlapping detection “zones” of multi-antenna stations within Chiniak Bay. We found that even in years of high productivity, and presumably high food abundance, kittiwakes often foraged out of the bay and beyond the detection range of receiving stations (15-20km). Data from conductivity loggers indicated that kittiwakes generally remained airborne when at sea during daylight hours. They periodically exhibited bouts of rapid transitions between air and water and in rare instances rested on the surface for longer periods of time (>30 min.). These daylight patterns were inverted during the night (one hour after sunset to one hour before sunrise) when kittiwakes mainly rested on the ocean’s surface for extended periods of time. Activity loggers and radio telemetry hold the promise of refining time budgets marine birds and providing a more-direct indicator of the “holy grail” of seabird ecology, food availability.

FALSE PRECISION IN MARINE BIRD SURVEYS – A COMMON PROBLEM.

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Boat-based surveys typically return a mean density estimate with associated confidence intervals (or other measures of variance) about the mean. Owing to the expense and time required in boat-based survey work, the results often derive from a single survey effort over a given area, in a given window of time. In these cases, the reported confidence interval reflects the dispersion of birds in the sample space. I propose this measure is trivial, and alone, conveys false precision. A more telling confidence interval would also reflect *temporal uncertainty* (e.g., day-to-day variance, or week-to-week variance) and *measurement error* (e.g., error in distance estimation, variable visibility, misidentification etc.) in the estimate. While we hope that variance due to these factors is constant or small, and thus dismissible, that hope is rarely justified. Biologists should conduct tests to quantify sources of variance in their surveys, and report those results. Then, attention can focus on decreasing extraneous variance through standardization or modeling. The result will be greater clarity, and increased power to detect population trends.

FORAGING STRATEGIES OF PELAGIC CORMORANTS IN THE GULF OF ALASKA

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Pelagic Cormorants (*Phalacrocorax pelagicus*) are widely distributed in the Northern Pacific Ocean. They are avian top predators that feed mainly on fish but also on shrimps or other crustaceans. Cormorants are pursuit-divers and thus their foraging and diving ecology is difficult to observe by

direct observations only. Our aim was to determine the spatial distribution of feeding areas and diving strategies to give us information on their foraging ecology. We used GPS data-loggers with integrated temperature and pressure sensors to investigate the foraging behaviour and diving activity of Pelagic Cormorants. We captured 14 chick-rearing males at Middleton Island in the Gulf of Alaska during the breeding season 2006 and equipped them with GPS data-loggers which were attached reversible to the lower back. After 1-11 days the birds were recaptured and the data loggers were removed to download the data. With these GPS and dive data we calculated the diving efficiency and trip duration, as well as number of dives per trip and number of trips per day. Throughout the whole study period, birds showed a clear preference for one foraging area located about 8km off the colony; they approached that area mostly by direct flights. Maximum dive depth was 42.2 m and maximum dive duration was 120 s (mean dive duration 51.1 s). Overall, the cormorants exhibited two major classes of dive depths, between 0-6 meters and 28-33 meters, respectively, and each bird tended to use the same depth range repeatedly. The fidelities to area and depth suggest that individuals remembered successful foraging trips and used this knowledge on successive trips.

THE ALASKA PELAGIC SEABIRD OBSERVER PROGRAM, YEAR ONE.

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Seabirds spend most of the year offshore, and in Alaska, non-breeding birds from southern regions may comprise nearly half the summer bird population. Managers need current information on the spatial and temporal distribution of birds at sea, over all seasons, to address conservation issues related to fisheries, shipping, oil exploration, and spills. Seabirds also serve as indicators of changes in marine ecosystems. The North Pacific Pelagic Seabird Database (NPPSD) contains historic at-sea survey data, primarily from the 1970's-1980's. Since then, many seabirds have declined and changes have occurred in ocean ecosystems. In 2006, the U. S. Fish and Wildlife Service received two-year funding from the North Pacific Research Board (NPRB) to reinstitute an at-sea monitoring program and to update the NPPSD. Collaborators include NOAA-Fisheries and other vessel-based research programs. Oceanographic and fisheries research vessels provide platforms for seabird observers, and the associated biological and environmental data of our collaborators will later be used for analyses of factors affecting seabird distribution. Between March and October, 2006, we joined 12 cruises for a total 168 days at sea, 146 survey days, and 14,263 km of survey transects. Coverage was greatest in the shelf edge and mid-shelf waters of the Bering Sea, but included areas in the Aleutian Islands and northern Gulf of Alaska. We record all marine bird and mammal observations into a gps-integrated computer, and distribution maps for the more common species can be accessed at the NPRB web site. In 2007, we will begin surveys in winter and spring, in collaboration with NOAA, BEST, and SBI projects.

SPRINGTIME IN THE NORTHERN BERING SEA; SEABIRDS OF THE ICE-EDGE IN 2006

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We conducted two seabird surveys near the ice edge of the Bering Sea, Alaska, in 2006, as part of a new U.S. Fish and Wildlife Service (USFWS) at-sea program. The USFWS program uses vessels of opportunity to collect data on abundance and distribution of birds at sea. For these spring cruises, we joined a USFWS Walrus survey onboard the 155 ft P/V Stimson (March 21-27) and the Shelf-Basin Interaction Project onboard the 420 ft USCGC Healy (8 May – 4 June). Surveys were conducted by one observer using a modified strip transect method to record all birds and mammals located within 300 m of the vessel in a 90° arc. The March survey covered 376 km of transects from St. Paul Island to ~150 km south of Nunivak Island in the eastern Bering Sea. Heavy ice was prevalent during the majority of transects ($n = 46$). Bird abundance was low in the March survey and mainly included gulls (*Laridae* spp.) and murre (*Uria* spp.). Bird abundance in May was higher than in March and included

a greater variety of species. The May survey was conducted in the polynia region south of St. Lawrence Island to the Bering Strait. During this survey sea ice was breaking up and ice coverage ranged from thick ice to open water. We covered 2,262 km ($n = 119$ transects) and observed >9000 birds; murres (*Uria* spp.) and northern fulmars (*Fulmarus glacialis*) were the most commonly encountered species. We also observed species of interest including ivory gulls (*Pagophila eburnean*), spectacled eiders (*Somateria fischeri*), and several species more typically associated with land. These survey data will be entered into the North Pacific Seabird Pelagic Database for future analyses.

PREFLEDGING BODY MASS LIMITS JUVENILE SURVIVAL IN SPECTACLED EIDERS: IMPLICATIONS FOR CLIMATE CHANGE AND RELEVANCE TO CONSERVATION

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We studied the factors affecting juvenile survival of female Spectacled Eiders (*Somateria fischeri*) breeding at a location on the Yukon-Kuskokwim Delta, Alaska. Individuals in our study were marked just prior to fledging at about 35 days of age, but were temporarily absent until observed breeding at age ≥ 2 . Such a delay in reproduction is a special case of capture-recapture methods and has been previously applied to seabirds. From 1999 – 2006, 402 ducklings were marked, and from 2002-2006, 41 of these individuals were observed on nests. Most individuals were first detected nesting at age 3 ($n = 16$), but some were first detected at age 2 ($n = 12$) and age ≥ 4 ($n = 13$). Models that incorporated pre-fledging body mass were best supported by the data, and juvenile survival increased with pre-fledging body mass ($\beta_{\text{mass}} = 5.1$ [95% CI: 1.3 – 9.0]). Juvenile detection probability increased with age, and by age 3 was slightly lower than estimates for adults, indicating that most individuals had begun breeding by age 3. Survival of adult females was 0.81 (SE = 0.02), which was within the range estimated in a previous study. Pre-fledging body mass has declined recently (2005 and 2006), perhaps from elevated salinity in ponds used during brood rearing. Our results demonstrate a link between environmental conditions on the breeding grounds and recruitment of this population.

SUB-LETHAL EFFECTS OF IMPLANTED SATELLITE TRANSMITTERS ON CAPTIVE COMMON EIDER (*Somateria mollissima*) FORAGING AT A DEPTH OF 5 m

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Small implantable platform transmitting terminals (PTTs) have been used to delineate populations and identify movement patterns of sea ducks, but the effect(s) on the carrier of such devices remains relatively unexplored. A central assumption in any marking study is that neither the mark, nor the marking process, affects measured parameters. Our study directly addresses this assumption and, to our knowledge, is the first to assess the potential short- and long-term effects of implanted PTTs on benthic foraging sea ducks. We trained six common eiders (*Somateria mollissima*) to dive to the bottom of a 5 m deep column for their food, allowed them to acclimate, and then implanted them with 38-47 g PTTs with percutaneous antenna. To assess the response of the birds to surgery and the implanted PTT, we collected biological samples and video dive footage; herein we present preliminary results. The first feeding dive took place 22 hours post-surgery. Five of the six birds were diving to the bottom within 35 hours of surgery. The remaining bird developed extreme lethargy and likely would have died in the wild. Short-term (≤ 15 days) changes were found in blood concentrations of general health,

immunological, metabolic, muscle condition and stress indices. Longer-term (1-3.5 months) changes were found in concentrations of general health, immunological and metabolic indices. These preliminary findings show that our experimental common eiders suffered deleterious effects in response to the implanted PTTs. Analysis of additional blood chemistries, as well as video footage, is ongoing.

COMPARISONS OF COMMON MURRE BREEDING PERFORMANCE AT THREE NEARSHORE CENTRAL CALIFORNIA COLONIES, 1996-2002.

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We monitored Common Murre (*Uria aalge*) breeding performance at three central California colonies that differed in size, geographic location and history (Point Reyes, Devil's Slide Rock, Castle Rocks) from 1996 to 2002. All three colonies declined dramatically in the 1980s mostly due to gill net and oil spill mortality. The northernmost, Point Reyes, is a relatively large, established breeding colony. Devil's Slide Rock, extirpated by 1986, was restored as a breeding site in 1996. Castle Rocks, the southernmost colony, is relatively small in size and has increased only modestly since the late 1980s. Mean egg lay dates tended to be earliest at Castle Rocks and latest at Point Reyes. Hatching success differed among colonies only in 1998 and 2002, when they were lower at Point Reyes. Fledging success and breeding success were consistently lower at Castle Rocks, while Devil's Slide and Point Reyes were similar in most years. Differences in phenology were likely due to earlier onset of upwelling and prey availability further south. Annual variation in phenology, fledging success and breeding success were associated with differences in SST; fledging and breeding success also were highly affected by disturbance events. Lower breeding success at Castle Rocks may be hindering colony growth. Possible reasons for this include avian disturbance, predation, and reduced prey availability. Consistently high breeding success at Devil's Slide Rock indicates conditions similar to a well-established colony, with high potential for future recruitment and growth.

MARINE BIRD BREEDING POPULATION TRENDS IN CALIFORNIA: UPS AND DOWNS OVER FOUR DECADES

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The Farallon Islands near the continental shelf-break off central California host the largest seabird community in the continental U.S. Breeding seabird populations at this offshore island, however, have exhibited sizeable declines over the last 30 years. Conversely, in recent decades seabird populations at inshore locations have increased and several new coastal colonies have formed and grown rapidly. New Brandt's Cormorant (*Phalacrocorax penicillatus*) colonies formed on Año Nuevo Island, Alcatraz Island, and Point Arguello in the early 1990s. Populations of Pelagic Cormorants (*P. pelagicus*), Western Gulls (*Larus occidentalis*), and Pigeon Guillemots (*Cephus columba*) also increased inshore. Ocean climate change and varying forage species dynamics likely contributed to these offshore declines and nearshore increases in seabirds. Specifically, the California Current experienced warmer than average oceanographic conditions from the late 1970s until the late 1990s. Additionally, seabirds preyed largely on rockfish in the 1970s and 1980s, but in the 1990s diet switched to anchovy, a species that occurs primarily inshore, as well as other demersal fishes. Starting in 2001–2002, offshore declines reversed for many seabird species, likely due to cooler ocean conditions since 1999 and a resurgence of rockfish and other prey. However, in 2006, increases stalled in central California during warm-water

conditions, reduced prey diversity and relatively low reproductive success since 2003, but not at Point Arguello. The recent warming event has been described as exclusive to the northern California Current and may not have been as influential at Point Arguello, a transition area between northern and southern water types.

COLD AND ANOXIC: FORAGING AREAS OF ENDANGERED AFRICAN PENGUINS AT MERCURY ISLAND, NAMIBIA, INFLUENCED BY SULPHIDE ERUPTIONS AND COLD WATER MASSES

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Mercury Island hosts the largest colony of African Penguins (*Spheniscus demersus*) in Namibia. Numbers of penguins are continuously decreasing, mainly due to food shortage after the collapse of their main prey item, Sardine (*Sardinops sagax*). Waters around Mercury Island are strongly influenced by local upwelling and frequent sulphide eruptions causing oxygen depletion in the water column. During the breeding season 2004-05 and 2005-06 we equipped several penguins with GPS depth temperature loggers at Mercury Island. Given the *in situ* measurement of water temperature during the birds diving, we are able to analyse the characteristics of water masses encountered by the birds additionally to the diving parameters and locations of foraging. Birds in both years used an area 15-20km north of the island to forage. Although the foraging area was almost identical in both years, oceanographic conditions varied between years. In 2005, the area was influenced by a recent hydrogen sulphide eruption and the birds reached water masses very low in oxygen and with temperatures between 12.6 and 12.9°C during foraging dives. In 2006, no sulphide eruption took place during the study, and birds showed a slightly different diving behaviour, diving less deep and foraging in slightly warmer water. The diet also varied between years, consisting in 2005 almost exclusively of Pelagic Goby (*Sufflogobius bibarbatus*), a species that seems to be more resilient to low oxygen than other possible prey fish. In 2006, penguins preyed on a variety of species, including pelagics, such as Sardine and Anchovy (*Engraulis capensis*).

THE DIET OF KITTIWAKES: WHERE HAVE ALL THE WHITING COME FROM? - A MYSTERY STORY FROM THE SOUTHEASTERN NORTH SEA

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In contrast to recent North Sea trends, breeding numbers of Black-legged Kittiwakes (*Rissa tridactyla*) from the only colony in German waters doubled since the 1990s and have only lately shown a stagnation. Diet is regarded as one of the key factors influencing breeding performance and trends in numbers. Thus, we analysed stomach contents of chicks and adults found dead during the breeding seasons 2002 and 2004 to disclose the secret of the success of German Kittiwakes. Young Whiting (*Merlangius merlangus*) with a mean length of 9 cm made up the main part of the diet both with regard to frequency of occurrence and proportion of prey items consumed. This result is consistent with former studies from the 1980s and 90s. As Whiting is generally classified as a demersal species, the Whiting in the Kittiwakes diet was earlier interpreted to originate from discard. Consequently, the studied Kittiwakes were believed to rely heavily on fisheries. Though, only low proportions of Kittiwakes were actually observed associated with fishing vessels in the southeastern North Sea. On the other hand, our own studies have shown that Kittiwakes concentrate along frontal structures in German North Sea waters. Although it has been impossible to directly assess the prey at the fronts while censusing kittiwake distribution simultaneously, there is evidence from other studies that Whiting

aggregates at fronts and could thus be a major prey of kittiwakes in frontal areas. So far, Whiting seems to present a reliable food source for German Kittiwakes.

AIRCRAFT AND BOAT DISTURBANCE TO COMMON MURRE COLONIES IN CENTRAL CALIFORNIA

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Aircraft and boat disturbance to Common Murres (*Uria aalge*) was monitored at three nearshore colonies in central California, 1997-2006: Point Reyes, Devil's Slide Rock, and Castle-Hurricane Rocks. Aircraft were subdivided by helicopters and fixed-wing (planes). To compare levels of disturbance to frequency of traffic in the area, all boats approaching within 1,500 feet (460 m) and aircraft overflights \leq 1,000 feet (305 m) of a murre colony were recorded. Prior to 2001, only numbers of events were recorded. From 2001-2006, numbers of events per hour also were determined for better comparability between colonies and years. Overall, planes were the most frequently recorded traffic but this varied between colonies. Helicopters caused the most frequent disturbances and impacted the greatest numbers of birds. Levels of disturbance varied considerably among years and colonies. Following high levels early in the study period, disturbance (particularly helicopters) declined over time at Castle-Hurricane following outreach efforts. However, the increase in disturbance by both boats and aircraft in recent years at Devil's Slide is cause for concern for this recently restored colony. Aircraft and boat occurrence is infrequent at the relatively remote Point Reyes colony.

POPULATION GENETIC STRUCTURE AND GENETIC DIVERSITY IN THE DOUBLE-CRESTED CORMORANT.

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Perceptions regarding Double-crested Cormorants (*Phalacrocorax auritus*) range from their role as an overabundant nuisance species to a potential conservation concern. Consequently, current management efforts for this species vary widely across North America according to local, rather than relative, perceptions of population status. Thus, a detailed understanding of population structure and taxonomy is necessary for delineating management units and implementing appropriate management. Four subspecies of Double-crested Cormorants have been described within North America: *P. a. auritus* breeds in northcentral and northeastern North America; *P. a. cincinnatus* breeds in Alaska; *P. a. albociliatus* breeds along the Pacific coast from British Columbia to Baja California and inland to New Mexico, Utah, Montana, and Sinaloa, Mexico; and *P. a. floridanus* is a resident in Florida and the western Caribbean. In this study, we examined the matrilineal history of the Double-crested Cormorant on a range-wide scale, looking at a 700bp fragment of the mitochondrial control region. A total of 180 individuals, grouped into 17 sampling locations, representing all currently recognized North American subspecies were studied. Analyses were conducted to examine population genetic structure and molecular variation within and between populations. Results characterize patterns of genetic variation over the species range and provide information relevant to conservation and management decisions.

TIME LAGS IN RESPONSE TO FOREST FRAGMENTATION: CASE STUDY WITH THE MARBLED MURRELET

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Species negatively affected by forest fragmentation may not immediately respond to such fragmentation if they have high site fidelity. We addressed this topic by estimating the probability of occupancy of potential nesting habitat (old-growth stands and stands with residual old trees) by Marbled Murrelets (*Brachyramphus marmoratus*) over a 12-year period on a forest managed for timber production. The stands were steadily fragmented over time. Using FRAGSTATS, we calculated fragmentation indices for each stand over four periods within the 12 years and related such stand variables to occupancy determined with audiovisual surveys. We also estimated mean canopy cover, reserve status, percent in residual old-growth, and tree size of each stand. Analysis with logistic regression showed that murrelets were less likely to occupy stands as they became fragmented (increasing edge to area ratio) and more often used stands with larger trees that were in protected parks. Occupancy showed a strong relationship to time since fragmentation, indicating that they were more likely to occupy a recently fragmented stand (reduced in size to <50 ha) than stands fragmented longer ago. These preliminary results suggest the recent historical configuration of the stand (within a few years) is important to consider when estimating the potential use of stands by murrelets for nesting. Our next step is to incorporate multi-scale analyses and detectability into the analysis to see if we can confirm this conclusion using the program PRESENCE.

BIRD ENTANGLEMENTS OBSERVED DURING BEACH MONITORING SURVEYS

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Three different groups along the West Coast of the United States conduct monthly beached bird surveys. COASST surveys along the coast of Washington from Whatcom County, Washington to Coos County, Oregon; Beach Watch surveys beaches from Sonoma County through San Mateo County, California; and BeachCOMBERS surveys beaches from Santa Cruz through San Luis Obispo Counties, California. Each of these citizen-scientist monitoring programs provides long-term baseline data on seabird mortality. This study investigates entanglement among bird carcasses from data collected by all three groups between 2001-2005. Land-based observations can provide an indication of entanglement occurrences at sea. We examined the species encountered as entangled, the rates of entangled carcasses encountered and the materials involved in the entanglements. The data were investigated for each program and compared between programs. The percentage of bird carcasses documented as entangled for each program was approximately 0.5% - 1.0% annually. A wide range of bird species were documented entangled in marine debris in the study area. The species observed entangled most frequently were Common Murre (*Uria aalge*) and Western Gull (*Larus occidentalis*). The entanglement materials were primarily fishing related (shore-based fishing); further research is required to determine the sources of the materials. It is recommended that the different beached bird monitoring programs adopt the same material categories for entanglement documentation in future surveys. The entanglements observed in carcasses during beached bird monitoring surveys are a conservative view of the actual entanglement rate that is occurring at sea.

WARM-WATER GADFLY PETRELS (*PTERODROMA* SPP.) OFF CANADA'S WEST COAST, OBSERVED FROM VESSELS OF OPPORTUNITY (1996 - 2005) - SENTINELS OF CHANGING OCEAN CLIMATE?

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Gadfly Petrels (*Pterodroma* spp.) are surface-feeding tubenose seabirds which occur throughout the Pacific Ocean. Although the marine ranges of many of these seabirds are poorly understood, they often inhabit specific oceanographic domains. Thus, interannual, or longer-term shifts in their distributions may indicate changing oceanic conditions. For example, increases in warm-water petrel sightings off the westcoast of North America have been attributed to warming of the California Current. In 1996, we initiated a program to survey seabirds along a 1500km transect (Line P), from Vancouver Island, British Columbia (Canada) to Ocean Station Papa (50.00° N, 145.00° W), using the Canadian Coast Guard Vessel 'John P. Tully'. In 2002, we began a second seabird survey program (in collaboration with the Pacific Continuous Plankton Recorder program) from British Columbia to Hokkaido (Japan) using the bulk-cargo carrier 'Skaubryn'. The two vessel-of-opportunity projects document spatial patterns and temporal fluctuations in upper-trophic predator community structure across a large swath of the subarctic North Pacific. Two observers (MB, MH) conducted >90% of all of the at-sea surveys examined. Here, we summarize the petrel sightings recorded during these two programs, and compare their seasonal and interannual occurrence and abundance along the Line P and the Continuous Plankton Recorder routes. The petrel species encountered during these two surveys include: Solander's (*Pterodroma solandri*), Herald (*P. heraldica*), Hawaiian (*P. sandwichensis*), Murphy's (*P. ultima*), Mottled (*P. inexpectata*) and Cook's (*P. cookii*). These time series of standardized observations provide a baseline to assess changes in the biogeography of the subarctic North Pacific.

CAN FORAGING DISTRIBUTION RESTRICT GENE FLOW IN A HIGHLY VAGILE SEABIRD?

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Despite their high vagility and potentially high gene flow between populations, many seabird species exhibit considerable levels of population genetic and phylogeographic structure. Previous studies found that this structure has been generated by both physical barriers as well as non-physical barriers to gene flow. Specifically, the Isthmus of Panama and the Eastern Pacific Basin seem to prevent gene flow in the pelagic masked booby (*Sula dactylatra*). In addition, masked booby populations within ocean basins seem to have become genetically differentiated, suggesting a role for non-physical barriers to gene flow. Previous research suggests that differences in foraging distribution may restrict gene flow among seabird populations, and that species that forage inshore are more likely to exhibit population genetic structure than offshore foragers. To test this hypothesis, we are comparing the phylogeographic and population genetic structure of the brown booby (*S. leucogaster*) to the masked booby. Although masked and brown boobies share many ecological traits, some evidence suggests that brown boobies forage closer to shore. We sequenced approximately 650 base pairs of the mitochondrial control region in 180 individuals from 6 populations distributed across the Pacific Ocean, Gulf of California, Caribbean Sea, and Atlantic Ocean to test the hypothesis that gene flow in the brown booby is

restricted by both the Isthmus of Panama and the Eastern Pacific Basin and that foraging distribution has influenced population differentiation within the Atlantic Ocean basin.

EVALUATING THE FATTY ACID SIGNATURE TECHNIQUE FOR STUDIES OF DIET COMPOSITION IN PISCIVOROUS SEABIRDS

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We sought to evaluate a non-lethal method for investigating piscivorous seabird diets that might circumvent some of the inaccuracies, conservation issues, and ethical concerns of more traditional diet studies. We compared fatty acid signatures of Caspian Tern (*Hydroprogne caspia*) chicks raised on mixed and monotypic diets of 2 fish types with largely different fatty acid profiles. Chick adipose tissue differed significantly in levels of 6 of 12 major dietary fatty acids between each of 4 diet treatment groups. A subsequent change in diet treatment resulted in significant changes in chick fatty acid levels within 14 days. Fatty acid levels in chicks that were switched from a mixed-fish diet after 20 days to a monotypic diet for 14 days were similar to those of chicks fed a monotypic diet throughout the 34-day treatment period. The ratio of the level of a particular fatty acid in the consumer compared to the food (calibration coefficient) varied by diet for 3 of 12 major dietary fatty acids, and varied by chick age for 9 of 12 major dietary fatty acids, independent of diet treatment. Fatty acid calibration coefficients for tern chicks were generally different from those for Common Murre (*Uria aalge*) chicks from a different study. Although fatty acid signatures of piscivorous birds clearly reflect the fatty acid composition of their diet, the variation in fatty acid calibration coefficients associated with variation in seabird diet, age, and species seems highly problematic for modeling diet composition using fatty acid signatures of seabirds and their prey.

AT-SEA MORTALITY PATTERNS OF MONTEREY BAY SEABIRDS

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Our understanding of seabird population dynamics and mortality is primarily derived from colony-based studies of fecundity and survival. Little is known about factors that regulate mortality at-sea during the non-breeding season. This is problematic because the effective evaluation of human impacts on seabirds requires a full understanding of fecundity and mortality during the breeding and non-breeding seasons. We examined seabird mortality at sea by combining two large, nine-year data sets from Monterey Bay, California: the Monterey Bay National Marine Sanctuary BeachCOMBERS beachcast animal surveys and the Center for Integrated Marine Technologies seabird survey program. We examined the relationship between physical and biological oceanography, seabird abundance at-sea and seabird mortality patterns. Seven species of seabirds were examined, including year-round residents and seasonal migrants. Generally, birds found dead on the beach tracks at-sea abundance in the summer months, but seabird mortality is higher than expected during the winter.

EFFECT OF EGG PRODUCTION ON DETERMINATION OF CLUTCH SIZE IN BLACK-TAILED GULL.

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Investigating the determinant factors in clutch size is a central issue in studies in life histories. As female birds produce many eggs simultaneously during short period, egg production could be great cost for energy and time, so it could limit clutch size physiologically. Gulls usually lay 1-3 eggs and rarely have a 4-egg clutch. In black-tailed gulls (*Larus crassirostris*), which are medium size of gull, about 60% of females lay two eggs and the maximum clutch size appears to be three. The reason why the black-tailed gulls with two eggs do not lay a third one has been unclear. To elucidate this, we investigated egg nutritional composition and duration for rapid yolk deposition to construct energy model for egg production. We found that female gulls of 3-egg clutches invested 40.5 % greater energy (1985 kJ) and took longer duration (20 days) to produce whole clutches than those for 2-egg ones (1413 kJ and 15 days). Females manage to reduce the daily energy demands for egg production by extending the duration for rapid yolk deposition when they produce larger clutches. It suggests that energy and nutrient invested to egg may be constrained in physiologically. In contrast to 3-egg females, 2-egg females could have a fast rapid yolk deposition by decreasing the number of eggs invested for same period and by increasing energy and nutrition to their eggs per egg and day. As a result, they may have similar clutch completion date to those for 3-eggs.

OF GLIMS AND GAMS, ERROR ESTIMATION, AND ECOLOGICAL MODELING: COMPARATIVE EVALUATION OF STATISTICAL METHODS FOR ANALYZING SEABIRD SURVEY DATA.

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Generalized linear models (GLiMs or GLMs) have become increasingly popular for analysis of a wide range of ecological data. This approach is parametric and includes a family of models, such as negative binomial regression (for count data), which is an extension of Poisson regression, and logistic regression (for presence/absence data). In contrast, generalized additive models (GAMs) are non-parametric, fitting a smoothing function to the data instead of a parametric function (which may be linear or non-linear). In this paper we contrast these two approaches to statistical analysis, using several examples of seabird survey data, modeling either abundance or presence/absence. The value of each method depends on one's objective. For descriptive purposes, the flexibility of GAMs, which does not assume fitting a function of a particular shape, outweighs that of GLMs. However, when it comes to the development and evaluation of ecological models, going beyond the original dataset, GLMs demonstrate their superiority. GLMs, unlike GAMs, provide explicit model equations, which are easily interpretable. Furthermore, the shape of the functional relationship to predictor variables can be statistically evaluated and one can identify the most parsimonious form, as we demonstrate. In particular, uncertainty about coefficients and associated predictions can be conveyed easily with GLMs, through presentation of standard errors and prediction intervals, which are not readily obtained from GAMs. We conclude by considering problems in estimating the appropriate errors for analyses of seabird survey data, which are characterized by a high degree of patchiness and potential spatial autocorrelation.

THE SCOPE OF ILLEGAL SHIP-SOURCE OIL POLLUTION AND POTENTIAL IMPACTS ON SEABIRDS OF BRITISH COLUMBIA

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Seabird mortality attributable to small scale ship-source oil pollution is a major conservation issue worldwide. British Columbia hosts approximately 80% of the global population of breeding Cassin's Auklets (CAAU: *Ptychoramphus aleuticus*). Three years of radiotelemetry data (1999, 2000, and 2001) for breeding adults tagged on Triangle Island (the largest CAAU breeding colony) show relatively aggregated foraging distributions centred off the shelf break west of the island. These foraging distributions are essentially bisected or lie adjacent to intense shipping routes and routes of vessels identified as known polluters. Is it possible that Cassin's Auklets are impacted by oil pollution without our detecting it? I used a trajectory model (GNOME – General NOAA Oil Modeling Environment) to simulate the trajectories of hypothetically oiled carcasses incorporating hourly sea surface wind data from Atmospheric Environmental Studies (AES) ocean buoys and seasonal surface currents (courtesy of M.G.G. Foreman, Institute of Ocean Sciences). I ran separate simulations for the first two weeks and last two weeks of June (carcasses likely persist afloat for less than 2 weeks), for each year from 1998 to 2006. Each simulation started with 10 000 oiled carcasses with locations based on the radiotelemetry data. Results indicate that most of the oiled carcasses would have sunk at sea, never reaching shore. A low proportion of the carcasses might reach shore but only in areas inaccessible for beached bird surveys, which are currently the most common means of monitoring seabird oiling rates.

FACTORS INFLUENCING WINTER MOVEMENTS OF KING EIDERS IN THE BERING SEA

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Recent satellite telemetry studies have shown that King Eiders (*Somateria spectabilis*) in the Bering Sea have a more dynamic wintering period than other sea-ducks, with extensive movements between different wintering sites. In this study we use satellite telemetry and remote sensing data to investigate potential factors that may explain the decision of individual King Eiders to move between wintering sites. We analyzed 176 distinct winter movements of 65 individual King Eiders, and compared variables recorded at departure and arrival times with random King Eider locations of stationary birds. Sea ice concentration and benthic biomass data for all locations were derived from satellite imagery. We analyzed the data by fitting multivariate mixed effects logistic regression models, with latitude, day length, sex, body size at capture time, year, sea ice concentration, and benthic biomass as fixed effects and individual as random effect. The model used for inference was selected by using a stepwise approach to remove insignificant variables. King Eiders were more likely to move during longer days and when ice concentration decreased. The response to the change in sea ice differed among latitudes and initial sea ice concentrations. Benthic biomass and body size had no explanatory value. Removing the random effect 'individual' resulted in very poor model performance, indicating that responses to environmental factors vary strongly among individuals. Age, physical condition and other factors associated with individuals may be important in influencing the decision of King Eiders to move in winter.

POST-BREEDING DISPERSAL AND PRE-BASIC MOLT OF MARBLED MURRELETS IN CENTRAL CALIFORNIA

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We identified important molting areas, characterized the timing of post-breeding dispersal and pre-basic molt, described post-breeding dispersal movements, and estimated changes in body mass during molt for Marbled Murrelets (*Brachyramphus marmoratus*) in central California from 1999-2003. Using mark-recapture, we estimated that 248-315 individuals out of 496-637 (43-50%) individuals used Año Nuevo Bay, located adjacent to nesting areas, for their pre-basic molt August-October. The mean date of primary molt initiation for individuals was 25 August and the mean date of completion was 3 October, resulting in an individual molt duration of 37 days ($n = 167$). Primary molt duration at the population level was greater (120 days) ranging from 2 August to 29 November, indicating that molt was asynchronous. The probability of long-distance dispersal from Año Nuevo Bay by radio-marked individuals was low during the breeding season (9-13%, $n = 46$), but was greater for murrelets radio-marked after the breeding season (69-90%, $n = 20$). The mean dispersal date for murrelets radio-marked in our post-breeding sample was 21 October and dispersal usually occurred a couple weeks after molt completion. Of 12 long-distance dispersal movements, 11 were to the south and one was to the north; mean dispersal distance was 238 km. Murrelets gained mass during molt, except during a moderate El Niño event in 2002 when mass did not change significantly. Apparently, sufficient prey resources in Año Nuevo Bay were available for murrelets to meet their basic metabolic requirements and the energetic demands of molt, even during warm-water conditions.

GENETIC STRUCTURE OF THE WESTERN GULL POPULATIONS SUGGESTS INCIPIENT SYMPATRIC/PARAPATRIC DIFFERENTIATION.

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Gulls within the “white-headed group” have been shown to have low-levels of genetic differences among populations, despite apparent morphological differences. In this study we examined population genetic structure of Western gull (*Larus occidentalis*) along the Pacific Coast of North America. Two subspecies of Western gull have been recognized on the basis of plumage coloration and body size; the northern subspecies, nominated *L. o. occidentalis* and the southern subspecies *L. o. wymani*, they are thought to overlap in central California. We analyzed variation in 9 microsatellite loci in gulls from 29 colonies sampled (N=300 individuals). We found strong genetic differentiation between northern and southern gulls occurring in central California between sampling sites in Año Nuevo and Monterrey Bay. This pattern supports the subspecies assignment. Strong genetic breaks can arise without geographical barriers in a continuously distributed species if the average individual dispersal distance and /or population size of the species is low. Because of the small distance between these two areas (30 miles of coastline), we speculate that the Monterrey Bay population may have originated from a recent range expansion of the southern population, which is largely distributed south of Point Conception. A number of possible scenarios for these Western gull populations are proposed based on life history characteristics and differences in nest site preferences and their availability.

SEXUAL DIMORPHISM AND THE FOOD HABITS OF NAZCA BOOBY ON MALPELO ISLAND, COLOMBIA.

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Malpelo Island, Colombia, in the eastern tropical Pacific Ocean supports the world's largest colony of Nazca Boobies (*Sula granti*). As part of a food habits study there during October 2006, we collected 90 regurgitation samples from 48 male and 42 female boobies that were returning to the island for the evening. Individual sample mass averaged 207 g (range 47 – 437 g), and the number of individual prey items per sample averaged 8.9 (mode = 6, range 1-81). The 809 individual prey items we identified included 14 species of fish and 1 ommastrephid squid (*Docidicus gigas*). The prey were mainly volant, epipelagic species with 90% of the total mass comprised of two taxa: flyingfish (Exocoetidae, 7 species; 54% of total prey mass) and a flying halfbeak (Hemiramphidae: *Oxyporhamphus micropterus*, 36% of prey mass). Surprisingly, the most numerous prey species was the lightfish *Vinciguerria lucetia*, a small mesopelagic species that represented 35% of the prey count but only 1.7% of the mass. Female boobies were significantly heavier than males (1.89 vs 1.60 kg), and they had longer and deeper bills. Although males carried smaller overall prey loads than females (205 vs 217 g), as a percentage of their body mass, male loads were heavier (12.8% vs 11.5%). Based on lengths of the most common prey, it also appeared that males captured a wider range of prey sizes than females. The adaptiveness of sexual dimorphism among sulids and its possible role in their foraging behavior remains unclear.

COLONY GIS: A NEW APPROACH TO MAPPING AND ANALYZING SEABIRD POPULATION PRODUCTIVITY.

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The Red-legged Kittiwake (*Rissa brevirostris*) is a small, cliff-nesting gull endemic to the Bering Sea region. Of the four known breeding colonies, the island of St. George supports 80% of the breeding population annually. Long-term monitoring efforts suggest that despite a location in one of the most energy-rich regions of the western hemisphere, coupled with minimal depredation of nests and adult birds, productivity trends show low average reproductive success to complete failure. The effects of changing ocean parameters have received much attention with respect to seabird productivity and population size, yet although the value of St. George Island as key breeding habitat is evident, little effort has been allocated to understanding how alterations in actual nesting habitat affect population size and performance. The dynamic cliffs of St. George Island provide a unique opportunity to examine this question by incorporating long-term field monitoring data from productivity plots, habitat mapping and small-scale GIS, predictive modeling across the entire cliff, and change detection methods over time using imagery. This colony GIS method may yield a more complete estimate of colony population productivity, and also has the potential for integration into a broad array of research endeavors worldwide.

MOLTS, PLUMAGES, AND AGE DETERMINATION IN ALCIDS

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To increase our knowledge of molts, plumages, and age determination, I examined 3,258 specimens of 20 species of North American alcids. Ten species exhibit the Complex Alternate molt strategy, six species appear to exhibit a Simple Alternate Strategy, and four species appear to exhibit the Complex Basic strategy. The prejuvenal molt of murrelets and razorbills occurs in two phases interrupted by molt suspension: body plumage, rectrices, and wing coverts are developed at the natal site whereas primaries and secondaries are developed at sea, concurrent with a preformative molt of body feathers, rectrices, and secondary coverts. Primary coverts are the only feathers retained from the natal site and allow identification of first-year birds. Ornamental plumes of several auklet and one murrelet species appear to be basic rather than alternate feathers. Whiskered and Rhinoceros auklets, supposed to have alternate

plumages, appear not to. On the other hand, Cassin's Auklet has a surprisingly extensive prealternate molt. Shape of the outer primaries can be used to age 14 species that develop juvenal primaries at the natal site but not to age six species that develop these feathers at sea. In eight species, molt-suspension patterns among primaries and secondaries can be used to age adults that had not undergone synchronous wing molts. Bill depth can be used to age six species through at least the second year. Data will be presented on a new measure that appears reliable for distinguishing live, first-year birds of all alcid species: width of the premaxillary process at the gape.

RECOMMENDATIONS FOR STANDARDIZING AT-SEA MONITORING PROGRAMS IN WEST-COAST NATIONAL MARINE SANCTUARIES

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The National Marine Sanctuaries (NMS) program is supporting the establishment of long-term, observer-based, at-sea monitoring programs, and standardized methods are needed. To make recommendations for West Coast National Marine Sanctuaries (WCNMS), I reviewed methodology of six past or on-going shipboard monitoring programs. Line-transect survey methods are recommended for marine mammals if feasible; however, it is anticipated that most WCNMS programs will lack the funding to perform adequate line-transect methodology and should employ strip-transect methodology. From survey heights of 8-15 m above sea level (asl), survey-area radii should be 300 m for most birds (90° quadrant) and 800 m for mammals (180° semicircle), and from 3-8 m asl these radii should be 200 and 600 m, respectively. Albatrosses and pinnipeds can be surveyed within the larger area. Observation distance should be binned into 100-m zones, allowing calculation of species-specific, maximum detection distances, ship-avoidance and ship-attraction behaviors, and detection biases by observers. Zones should be recorded according to closest approach rather than first detection. Three observers observing "collectively" (assisting one another) should be used to cover these areas and enter data. Protocols for monitoring debris and vessels have been developed and are being tested. A modified version of the *SeeBird* computer-entry program was developed by Southwest Fisheries Science Center specifically for WCNMS surveys and will be demonstrated to indicate recommendations for weather, behavioral, age, sex, and morph categorization. A database listing alpha codes for all WCNMS programs would allow direct data interfacing for planned, broad-scale analyses and on-line availability.

OF CORMORANTS AND CRANES.

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Double-crested cormorants nesting on the steel girders under the eastern portion of the San Francisco-Oakland Bay Bridge will lose their habitat when the seismically unsafe bridge is removed. Damaged in the 1989 Loma Prieta earthquake, the 1935 vintage bridge was determined to be unfixable so a replacement span was designed. Construction finally began in 2002 and the new cement bridge is two-thirds complete. A recent addition to the bridge has been the placement of nesting platforms for double-crested cormorants to replace the habitat that will be lost on the old bridge. Designed by Mark Rauzon, these stainless steel mesh platforms were estimated to cost about \$550,000, making them the "world's most expensive bird houses". The entire bridge itself is now estimated to cost \$7 billion and be completed in 2013. The nesting platforms were erected in Oct-Nov. 2006 (sooner than predicted) and have been covered with chicken-wire mesh to prevent birds from using the habitat until the entire bridge is complete. Construction of the new bridge, approximately 100 meters from the old bridge, has exposed the existing colony to noise and intense construction activities. The colony size in 2004 was estimated to be 723 pairs, while 446 pairs were counted in 2005. No count was made in the breeding season in 2006 but the colony appears to continue to decline as judged by number of old nests seen in November.

GIS-BASED CENSUS OF BURROWING PETRELS: A CASE STUDY USING THE COOK'S PETREL.

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Estimating the numbers and distribution of endangered species with cryptic life history traits is a critical component of conservation efforts. The Cook's petrel (*Pterodroma cookii*), is endemic to the New Zealand archipelago breeding on only 2 offshore islands. This study utilised a novel application of GIS-based predictive habitat modelling to quantify for the first time the size of the Cook's petrel colony on Little Barrier Island. Survey results identified a disjunct distribution with birds breeding only above 300 metres altitude. Using multimodel inference a generalised linear model of Cook's petrel burrow abundance was developed incorporating the topographic predictors of altitude, slope, and distance to ridge tops. This model was able explain 31% of the variance in burrow distribution. When applied to GIS-based datasets of the study site, in conjunction with burrow occupancy data, results indicated that this population consists of more than 286,000 breeding pairs of Cook's petrel. This value is six times greater than previous estimates for Little Barrier Island and the result supports the need for new methods to improve our understanding of seabird populations.

STEALING FROM THE MOUTHS OF BABES: GULL KLEPTOPARASITISM RATES AND THE EFFECT ON TERN COLONY SIZE AND PRODUCTIVITY.

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The Caspian Tern (*Hydroprogne caspia*) colony at Crescent Island, on the mid-Columbia River in eastern Washington, has declined 32% from 2001 (657 breeding pairs) to 2006 (448 pairs). Additionally, the productivity of this colony has plummeted from 1.07 chicks fledged per pair in 2001 to 0.43 in 2006. These declines are puzzling because the regional population has remained stable during this period and the annual food supply at Crescent Island is presumably relatively constant due to high levels of hatchery production of juvenile salmonids (*Oncorhynchus* spp.), the terns' primary prey at this location. One unique aspect of this tern colony is a high rate of kleptoparasitism by California Gulls (*Larus californicus*), which nest in large numbers on Crescent Island (ca. several thousand pairs). The proportion of fish transported by terns to this colony that were kleptoparasitized was more than twice that at other Caspian Tern colonies we have monitored, such as at East Sand Island near the Columbia River mouth. If gull kleptoparasitism has impacted the Crescent Island tern colony, we would expect to see a negative relationship between kleptoparasitism rates and productivity; however, we saw a downward trend in both productivity and kleptoparasitism during 2001-2006. Kleptoparasitism rates declined from 19.3% in 2001 to 14.1% in 2006. Other factors, such as smaller fish size, less profitable species (fewer large steelhead [*O. mykiss*] smolts in diet), and/or more gulls in the tern colony may be influencing both tern productivity and the motivation of gulls to steal fish from terns.

PATCH OCCUPANCY MODELS IMPROVE AREA ESTIMATES OF AUKLET COLONIES

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Patch occupancy models provide an unbiased estimate of the area occupied by, e.g. a seabird colony. Repeated sampling allows for simultaneous estimation of detection and occupancy rates, which both remove sampling bias and allow uncertainty estimates. Bias is especially high in low-density applications. Note that the found occupancy rate is irrevocably tied to an a-priori selected sampling scale. We used these models and two other occupancy estimation techniques in 2006 on Segula and St. George islands to evaluate and improve a standardized method for mapping auklet colonies. The initial protocol employs a randomized systematic grid survey; we added repeated multiple sampling which supports fitting patch occupancy models to account for less than perfect detection. We also tested an “expert search” method which incorporates the experience of the researcher in identifying occupied cells. However it is less reproducible, does not support estimates of uncertainty, and is still subject to potentially bias in low density colonies. Patch occupancy models produced a higher area estimate (up to 1.2 times higher than the “expert” method, and two times higher than the “standard” method). A combination of both approaches appears to provide the most useful information in terms of both unbiased colony area estimates and standard errors as well as explicit georeferenced maps of known occupied cells.

Patch occupancy models should be considered in any study dealing with presence-absence data.

CONTRASTING SUMMER AND WINTER DISTRIBUTION OF PLANKTIVOROUS SEABIRDS IN THE ALEUTIANS

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The waters of the Aleutian Archipelago attract seabirds in globally significant densities during the northern summer, but little is known about their role during winter. Using data collected during surveys for marine birds and mammals, we compare the summer and winter distribution of seabirds around three sites: Buldir in the western, Kasatochi in the central, and Aiktak in the eastern Aleutians. In contrast to the sites further west, the overall density of seabirds at Aiktak is greater during winter than during the breeding season, despite the departure of many species (e.g. shearwaters). A pattern of decrease from summer to winter in the western and central Aleutians, and an increase in the eastern Aleutians, is shared by several species. The pattern is most evident in species that are believed to prey mostly on euphausiids, and is most pronounced in Crested Auklets (*Aethia cristatella*).

WHY DO SHALLOW DIVING CORMORANTS DESCEND THE WATER COLUMN AT RELATIVELY SMALL DIVE ANGLES?

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For cormorants foraging underwater in search and pursuit of benthic prey, buoyancy imposes a mechanical constraint on the adaptation to aquatic lifestyle. Buoyancy is reduced with depth due to compression of the air volumes in the plumage and respiratory tract. Therefore, logic has it that birds diving at shallow sites, where buoyancy is high, should prefer to descend to the bottom vertically and then swim along the bottom. In practice, shallow diving cormorants have been often observed descending the water column at relatively small descent angles (45° relative to the water surface). In this work we provide a hydrodynamic model of the mechanical work required to reach the bottom during a dive of a foot-propelled avian diver. The model estimates the change in paddling frequency and buoyancy as a function of depth to calculate the work against buoyancy and drag and finds the optimal descent angle to reach a specific point on the bottom. We show that depending on bottom depth and optical conditions the birds can benefit energetically from descending at small angles relative

to the horizon. The model can also explain the high variance in dive angles observed in free ranging birds and the correlation between dive depth and descent angle.

ON THIN ICE: REDUCTION OF DIVE COSTS BY SPECTACLED EIDERS WINTERING IN THE BERING SEA

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The Spectacled Eider (*Somateria fischeri*), a Threatened species, winters in pack ice of the Bering Sea. It dives to 40–70 m for benthic prey, high energy costs of foraging are offset by high benthic biomass. Unlike other diving ducks which use drag-based foot propulsion, sea ducks have adopted wing propulsion as their major locomotor mode for deep diving. However, despite use of these two swimming modes by different seabirds (e.g. alcids vs. cormorants), their relative costs have never been measured in the same species. With respirometry, we measured the costs of surface activities (swimming and preening), and costs of diving by different swimming modes (feet only vs. feet and wings used together) in the same seaduck species. To avoid using a Threatened species for experiments, we used white-winged scoters (*Melanitta fusca*) which are similar in body size and diving behavior to spectacled eiders. For scoters in 9 °C water, costs were 0.416 ± 0.027 and 0.642 ± 0.025 ml O₂/s for swimming and preening, respectively. For dives to 2 m, costs above resting metabolic rate for time spent underwater was 21% lower for mainly wing-propelled than for foot-propelled dives. Stroke rates were higher for foot propulsion, but vertical speed was higher for wing propulsion. Thus, wing propulsion lowers dive costs and increases vertical speed, yielding longer bottom time for the same total dive time. Our results show that for deep-diving seaducks, use of wing propulsion can lower energetic costs of diving providing longer foraging times and overall higher energy rewards.

HABITAT OR LOCATION: WHY BROWN PELICANS USE DIFFERENT ROOST SELECTION STRATEGIES DURING DIFFERENT TIMES OF YEAR

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Numbers of California Brown Pelicans (*Pelecanus occidentalis californicus*) roosting along the coast of central California begin increasing in late April and peak in fall/winter. While in this area, pelicans have a range of roosting habitats from which to choose. We conducted surveys of Brown Pelican roosts at Vandenberg Air Force Base located at the southern end of central California. We conducted surveys on 3 consecutive days, twice a month from March 2001 through February 2006. We placed all roosts in 1 of 5 habitat categories (islet, cliff, river/creek mouth, detached rock, or attached rock) and calculated the diversity of locations attended during each survey using the Shannon diversity index. We related roost utilization to three environmental factors (wind speed, wave height, and tidal height) and three factors related to prey availability (sea surface temperature, anchovy larvae abundance, and presence of pelican foraging flocks). Location diversity was positively related to sea surface temperatures and presence of foraging flocks, and negatively related to wave height. Anchovy abundance was also positively related to sea surface temperature. As sea surface temperatures increase, anchovies aggregate in nearshore waters to spawn. During this period, pelicans use more diverse habitat types and foraging flocks begin to appear. Roost selection at this point appears to be geared toward proximity to locally available prey. As sea surface temperatures subside and wave heights increase in fall/winter, pelicans shift roosting strategies and mainly select elevated habitats that provide shelter against adverse environmental conditions.

USING TOP PREDATORS TO ASSESS THE EFFICACY OF THE VANDENBERG STATE MARINE RESERVE

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The Vandenberg State Marine Reserve (VSMR) was established in 1994, but its efficacy in protecting local marine populations has yet to be tested. We tested the hypothesis that lower trophic level organisms are more abundant inside the VSMR than outside by monitoring the foraging habits of four seabirds (Brandt's and Pelagic Cormorants, Pacific Loons, and Surf Scoters) and two marine mammals (harbor seals and California sea lions). In theory, the abundance and species composition of foraging predators will reflect the community structure of lower trophic level organisms within a given habitat. We measured foraging rates at study plots inside and outside the reserve using a paired design. The VSMR spans the coastal boundary of Point Arguello and we controlled for headland effects by selecting one pair of study plots on the windward side and one on the leeward side of the promontory. All species but harbor seals showed either no difference or a higher abundance outside the reserve than inside. Additionally, the three demersal fish specialists (harbor seal and Brandt's and Pelagic Cormorants) foraged more in leeward plots than windward while the benthic invertebrate specialist (Surf Scoter) foraged more in windward plots. Our results suggest that prey abundance is not enhanced inside the VSMR. Possible explanations include inadequate reserve size for prey with large home ranges or, conversely, fishing pressure in the area is too low to impact areas outside the reserve. Our results also suggest a strong difference in benthic community structure between windward and leeward habitats.

CASPIAN TERN PREDATION ON SALMONIDS IN THE MID-COLUMBIA RIVER: MAGNITUDE OF IMPACT ON SURVIVAL OF ESA-LISTED STOCKS.

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Caspian Terns (*Hydroprogne caspia*) nesting at the world's largest colony on East Sand Island in the Columbia River estuary are currently the focus of efforts by resource management agencies to reduce avian predation on ESA-listed salmonids (*Oncorhynchus* spp.) from the Columbia Basin. The Caspian Tern colony on Crescent Island, a dredge spoil island in the mid-Columbia River, has received comparatively little attention from management agencies because of its relatively small size (ca. 500 pairs, 1/20th the size of the estuary colony) and low annual consumption of salmonids (ca. 500,000 smolts, 1/10th the consumption of the estuary colony). To measure tern predation rates on salmonids, we recovered smolt PIT tags from the Crescent Island colony, and corrected recovery rates for PIT tag detection efficiency and proportion of ingested tags deposited on-colony. Predation rates on some ESA-listed Upper Columbia River and Snake River salmonid stocks, particularly steelhead, were surprisingly high. For example, predation rates on threatened wild Snake River steelhead (in-river migrants only) were 29.5%, 14.5%, and 7.6% in 2004, 2005, and 2006, respectively. Comparable predation rates for hatchery-reared Snake River steelhead were somewhat higher: 37.5%, 18.6%, and 12.3%, respectively. Predation rates by Crescent Island terns on Snake River steelhead were higher in years of lower river flows and reduced spill from hydroelectric dams. The unexpectedly high predation rates on some ESA-listed salmonids by the Crescent Island Caspian Tern colony reflect the high proportion of salmonids in the diet and the high vulnerability of steelhead smolts to Caspian Tern predation.

CAN MARBLED MURRELETS ADJUST FORAGING EFFORT IN POOR YEARS: FLEXIBLE FORAGING IN VAIN?

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Studying the reproductive success and foraging ecology of Marbled Murrelets (*Brachyramphus marmoratus*) has been extremely difficult because of their cryptic nesting behaviour. Instead, murrelets may be monitored more easily by observations at sea, perhaps elucidating otherwise difficult to determine reproductive and foraging parameters. We used instantaneous scan sampling techniques at 12 sites over three years to study the foraging behaviour of murrelets on southwestern Vancouver Island. Measures of adult (AHY) densities, juvenile (HY) densities and HY:AHY ratios suggested good conditions in 2004, extremely poor conditions in 2005, and poor conditions for AHY birds but excellent conditions for chick rearing in 2006. Autocorrelation analysis revealed sustained foraging activities over 2 to 3 hour periods only in 2005. Generalized linear models and an Information Theoretic approach was used to model temporal, spatial, environmental, and inter/intra-specific factors affecting foraging activity. Temporal variation (Year, Breeding Phase, and Time of Day) had the greatest impacts on foraging behaviour, but some variation in foraging was also explained by spatial factors. To compensate for poor conditions, murrelets increased and sustained their foraging activity in 2005. In 2006, when conditions were poor for adults, murrelets increased foraging effort during daytime hours relative to dawn or dusk periods. Nevertheless, despite their apparently flexible activity budgets, increased foraging effort in 2005 was inadequate to ensure normal levels of reproductive success. Thus, flexible foraging behaviour by murrelets may be in vain when environmental conditions are extremely poor.

JOURNEY TO THE REMOTEST PLACE ON EARTH: DIET, STAGING, AND MIGRATION OF THE GREATER SHEARWATER

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Seabirds undertake formidable migrations, traversing large portions of the globe over short time frames. To realize such feats, birds must find staging grounds where they can replenish depleted body reserves. The Greater Shearwater (*Puffinus gravis*) faces such a challenge when traveling from its northern wintering grounds to breeding areas in the most remote inhabited place on earth, the Tristan da Cunha islands in the South Atlantic. Our study integrated satellite telemetry with data on diet and mass gain to provide a descriptive model of staging and migration by the Greater Shearwater. In the Bay of Fundy (BoF), Canada, we captured 136 Greater Shearwaters over two summers, and obtained dietary information from them using stable isotopes. We also attached satellite transmitters to six individuals. In both years, the shearwaters gained mass while staging in the BoF, with a peak in mass in late August, just prior to migration. Dietary source influenced mass gain: birds feeding at lower trophic levels (euphausiids) weighed less than individuals feeding at higher trophic levels (fish). Migration from the BoF to feeding grounds off the coast of Argentina/Uruguay took 26 days on average, followed by a mean staging period of 35 days before heading to breeding grounds at Tristan. Timing of migration, staging, and arrival at the Tristan colony was highly synchronous. The longest track was over 32,000 km in 109 days. Thus long distance migration of Greater Shearwaters requires significant staging periods where body reserves are replenished by foraging on high trophic level prey.

MONITORING MURRES AND KITTIWAKES AT CAPE LISBURNE, ALASKA, 1976-2006

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Cape Lisburne in the eastern Chukchi Sea supports an estimated 400,000-500,000 common and thick-billed murres (*Uria aalge* and *U. lomvia*) and 20,000-30,000 black-legged kittiwakes (*Rissa tridactyla*) on about 7 km of precipitous, near continuous 15-200 m-high sedimentary limestone and shale sea-cliffs (about 30% of the murres are common murres and 70% are thick-bills). This large impressive seabird colony is one of the Alaska Maritime National Wildlife Refuge's 10 annual monitoring sites and the northernmost breeding location for these cliff-nesting species in Alaska. Murre and kittiwake populations have been monitored at Cape Lisburne since 1976. Based on 1976-2006 boat- and land-based counts, numbers of murres increased slowly during the mid-1970's – mid-1980's, more than doubled during the mid-1980's – late 1990's, and then began gradually declining after 2000. Numbers of kittiwakes and their nests also increased at the colony during the mid-1970's – late 1990's, but these positive trends were limited to the west-facing cliffs. More recent land-based counts made during 2002-2006 suggest that numbers of birds may be starting to increase on the north-facing cliffs, although numbers of nests have remained relatively stable in this sector of the colony. The average productivity of these small gulls was lower in 1992-2006 than it was during 1976-1987 (0.5 vs. 0.9 eggs/chicks per nest). This change may be related to increasing sea-surface temperature and the earlier break up, dissipation, and retreat of sea-ice.

THE SEABIRD TISSUE ARCHIVAL AND MONITORING PROJECT (STAMP) AND COMMUNITY INVOLVEMENT

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The Seabird Tissue Archival and Monitoring Project (STAMP) is a collaborative effort by the U.S. Fish and Wildlife Service's Alaska Maritime National Wildlife Refuge (USFWS-AMNWR), the U.S. Geological Survey-Biological Research Division (USGS-BRD), the National Institute of Standards and Technology (NIST), the Bureau of Indian Affairs Alaska Region Subsistence Branch (BIA-ARSB), and 19 Alaskan communities to monitor long-term (100-year) trends in persistent, potentially harmful bioaccumulative contaminants in the Bering and Chukchi seas and Gulf of Alaska using murre (*Uria aalge* and *U. lomvia*) and gull (*Larus hyperboreus*, *L. glaucescens* and *Rissa tridactyla*) eggs and other seabird tissues. STAMP collects, banks, and analyzes the eggs and tissues for about 100 potentially harmful persistent bioaccumulative toxins (PBT's), including polychlorinated biphenyls (PCB's, 65 congeners), dichlorodiphenyltrichloroethane (DDT, 6 related compounds), chlordanes (6 related compounds), hexachlorocyclohexane (HCH, 3 congeners); hexachlorobenzene (HCB), toxaphene, dieldrin, mirex, polybromated diphenyl ethers (PBDE's, 12 congeners), organotins (several closely related compounds), and mercury. STAMP was initiated in 1999 and began directly involving rural communities and local residents in the egg collecting work in 2002. As of 2006, people from 19 Alaskan communities and 1 in the Commander Islands in Russia have helped collect murre and gull eggs at 22 different seabird nesting locations. Public participation has become a key component of the STAMP program and will be expanded to other coastal and insular areas of Alaska and the Russian Far East. The National Pacific Research Board is currently supporting some of the analytical work (NPRB Project 534).

ANNUAL PREY CONSUMPTION OF COMMON MURRES FROM CAPE BLANCO, OREGON TO POINT CONCEPTION, CALIFORNIA.

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Common Murres are one of the most abundant seabirds along the western coast of the United States and can have a substantial impact on prey populations. We used data on population size, diet composition, field metabolic rate, energy densities of prey species, and assimilation efficiency from the literature to estimate annual consumption of murres between Cape Blanco, Oregon and Point Conception, California. We estimated that the murre population in our study area consumed 248 874 metric tons annually, including 129 090 metric tons consumed by adults during the breeding season, 119 638 metric tons consumed by adults present during the wintering period, and 147 metric tons consumed by chicks at breeding colonies. Pacific whiting and market squid each made up over 20% of adult annual consumption at 61 516 metric tons and 58 457 metric tons, respectively. Other species making up at least 10% of annual consumption included shiner surfperch (28 596 metric tons), northern anchovy (27 574 metric tons), and rockfish species (23 954 metric tons). Chick diet was dominated by anchovy / sardine (53.6%), rockfish species (25.5%), and smelt species (9.0%). Variation in adult population size and field metabolic rate had the greatest effect on estimates of prey consumption. Understanding the impact of seabirds and other top predators on prey populations is important for understanding the dynamics of predator and prey populations and for effective management of ocean resources.

LOCAL PRIMARY PRODUCTIVITY REFLECTED IN SEABIRD ABUNDANCE AND DIVERSITY IN A NEARSHORE ENVIRONMENT

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Conceptually, phytoplankton is the base of the food web that supports piscivorous sea birds. Phytoplankton should support zooplankton, which in turn supports fish, ultimately supporting piscivores. We use chlorophyll density as a possible measure of phytoplankton abundance. We focus on a near shore system (depth < 50m) where we can measure chlorophyll density in the entire water column. Chlorophyll density measurements and ship-based seabird surveys were conducted in Estero Bay (Central California). We test whether chlorophyll density is associated with seabird diversity and abundance during the upwelling season in this near shore environment. Our results are useful for understanding the scale at which seabird abundance and diversity is affected by variation in primary productivity.

THE IMPACT OF THE NON-NATIVE EUROPEAN RABBIT ON BURROW ACTIVITY, HATCHING SUCCESS AND CHICK SURVIVAL OF THE PINK-FOOTED SHEARWATER

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The introduction of non-native mammals to island ecosystems is a problem that plagues many native island species. Previous studies have qualitatively documented negative impacts of non-native rabbits on island seabird communities, but few quantitative assessments exist. We measured the direct impact of non-native European rabbits (*Oryctolagus cuniculus*) on pink-footed shearwater (*Puffinus creatopus*) breeding colonies on Santa Clara Island, Juan Fernández Islands, Chile. Using an infrared camera probe, we compared breeding activity (% of burrows used for breeding in a season), hatching success and chick survival measures between three subcolonies during the 2002-2006 breeding seasons. We took advantage of a natural experiment to compare these measures in two years (2002-2003) prior to and three years (2004-2006) following a successful rabbit eradication program on the island. Breeding activity was significantly lower prior to eradication (51%) compared to post-eradication (56%), but hatching success and chick survival through the mid-chick period did not differ.

Breeding activity also varied between colonies within a year in three seasons. These results suggest that rabbits may have an important disruptive effect on shearwater breeding activity early in the season, possibly through direct competition for burrows. However, once eggs have been laid, rabbits do not appear to affect hatching and subsequent chick survival.

POPULATION TRENDS OF BREEDING SEABIRDS IN THE HAWAIIAN ISLANDS: IS THERE EVIDENCE OF RECOVERY AND DENSITY DEPENDENCE?

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Throughout the first half of the 1900's, seabirds in the Northwest Hawaiian Islands (NWHI) suffered from hunting, persecution, or introduced predators. Since the second half of the 1900's, there has been an extensive effort to improve the conditions for these and other NWHI species. These actions have included decreasing human disturbance, eradicating rats and invasive plants, and removing collision and entrapment hazards. As part of a larger project to assess seabird monitoring methods for National Wildlife Refuges in the U.S. Pacific Islands, we used long-term monitoring data to model population dynamics of breeding populations. We compared density independent (exponential growth or decline) and density dependent models. For most species, both models suggested that the number of breeding seabirds had increased over the last 10-20 years. For many species, the simpler density independent models were better supported. These models suggested increasing seabird populations that are not yet limited by density dependence. However, for some species, density dependent models were equally well supported and may be biologically more realistic. These models suggest that identifying the mechanism of density dependence (e.g., nest-site competition versus foraging competition) may aid in the management of these species. These models demonstrate the utility of long-term monitoring data for understanding population dynamics of breeding seabird populations in the NWHI.

AT SEA DISTRIBUTION OF FORAGING LITTLE AUKS (*ALLE ALLE*) ALONG THE WEST-COAST OF SPITSBERGEN: DO THEY AVOID WARM ATLANTIC WATER?

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The west-coast of Spitsbergen, Svalbard is influenced by two major current systems: Cold Arctic water originating from the northern Barents Sea and warmer Atlantic derived water as the northernmost extension of the Atlantic inflow into the Nordic Seas. The intensity of the inflow of Atlantic water varies inter-annually and increases gradually along the coastline from south to north creating a heterogenic pattern of both discrete and mixed water masses. The different water masses can be characterized by an associated distinct zooplankton community, with Arctic water containing a high proportion of the little auk's predominant prey species, the copepod (*Calanus glacialis*). Previous studies have reported a close correspondence of foraging Little auks and the distribution of Arctic derived water masses. Due to a lower occurrence of their main prey species, foraging adult little auks might avoid Atlantic waters. However, these findings were primarily derived from areas with a distinct influence of Arctic waters. By comparing three fjord systems with different water regimes we studied potential changes of the Little auk's foraging behaviour along a gradient of an increasing inflow of Atlantic water. During the breeding season 2006 standardized strip-transects were performed in the Hornsund area, Isfjorden and in the Kongsfjorden-Krossfjorden system in order to identify the main foraging areas. The results were interpreted with regard to the physical oceanographic conditions using sea surface temperature and conductivity, temperature, depth (CTD) data.

THE STATUS OF BREEDING SEABIRDS ON THE ERITREAN RED SEA ISLANDS.

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There are very large numbers of birds on the coasts and the islands and respectively on the shallow water of the Eritrean Red Sea. Breeding adult and nest count were conducted by walking slowly along the colonies of each breeding birds. According to the surveys done on 2005 and 2006, in total 23 species of seabird and shorebirds were found to breed. Majority of the birds breeds on summer. Some of the important populations include Crab Plover (*Dromas ardeola*) the largest colony was recorded on Delgus (Assab bay), which hosts 1600 burrows, which is the biggest colony in the world. White-eyed Gull (*Larus Leucophthalmus*) the bird is endemic to the Red Sea and Gulf of Aden and is globally threatened. In total 3,200 breeding pairs were recorded on 45 islands. Lesser-Crested Tern (*Sterna bengalensis*) the largest colonies were recorded on Sheik El Abu, which hosts 15,000 pairs and Modjedih, which hosts 12,000 breeding pairs. In total 91,000 breeding pairs were recorded on 28 islands, White-Cheeked Tern (*Sterna repressa*) 5,000 breeding pairs were recorded on 51 islands, Osprey (*Pandion haliaetus*) breeding adults recorded on 84 islands. In general the entire Eritrean islands may support up to 250,000 breeding birds in summer and winter. The large numbers of islands, which are almost uninhabited, free of potential predators, suitable breeding habitats and with sufficient food supplies result to support very large number of breeding seabirds on the Eritrean islands. Currently the potential disturbance to breeding seabirds on the islands comes from local and foreign sea cucumber fishermen.

ALBATROSSES AS OCEAN SAMPLERS OF SEA SURFACE TEMPERATURE.

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Albatrosses are unique ocean voyagers because they range so widely and travel at speeds exceeding 90 km per hour. Between 2003-2005, 21 breeding Laysan (*Phoebastria immutabilis*) and 15 breeding black-footed albatrosses (*P. nigripes*) were equipped with 6 g leg-mounted geolocation archival data loggers at Tern Island, Northwest Hawaiian Islands. Loggers sampled environmental temperatures every 480 or 540 s and provided a single location per day. Whenever an albatross landed on the sea surface to feed or rest, the tag sampled sea surface temperature (SST). After nearly one year of deployment, 31 albatrosses were recaptured and 29 tags provided complete records. A total of 377,455 SST readings were obtained over 7,360 bird-days at sea. Given the location errors in the geolocation methodology (200 km) and the lack of temporal resolution (1 location per day), the SST measurements can only be used to characterize broad-scale correlates between albatross distribution and the ocean environment. However, in February 2006, we deployed 45 g GPS data loggers on 10 breeding albatrosses for 2-4 day deployments. The GPS loggers sampled every 10 s, and were accurate to within 10 m. One albatross was equipped with an archival tag that sampled SST every 8 s. This albatross collected 6,289 SST measurements with complementary GPS quality locations in 3 days at sea. These results highlight the efficacy of albatrosses as ocean samplers, their probable use as sentinels of changing oceanic conditions, and provide exciting new information about the oceanic habitats of North Pacific albatrosses.

OCEANIC HABITAT USE AND DIVING BEHAVIOUR OF SOOTY SHEARWATERS (*PUFFINUS GRISEUS*) IN NEW ZEALAND WATERS.

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Observations of habitat use and at-sea behaviour of small seabirds have generally been limited to vessel-based platforms. However, recent advances in microprocessor-based electronics have now produced data logging devices small enough for deployment on seabirds less than 1 kg. We studied the oceanic habitat use, diving behaviour, and at-sea activity of sooty shearwaters (*Puffinus griseus*) in New Zealand using 6 g archival geolocation loggers measured location, environmental temperature, and diving depth. Two distinct patterns of habitat use were observed. Shearwaters either traveled to oceanic waters in the Antarctic Convergence (Range from colony $2,514 \pm 238$ km), or remained within coastal waters off New Zealand (Range from colony 368 ± 206 km). Total distance traveled, distance per day, and mean travel rates were all greater for shearwaters traveling to oceanic waters compared to shearwaters that remained within coastal waters. Diving behaviour (mean max depth 15.9 ± 10.8 m, max depth 69.9 m, N = 2,007 dives) did not differ dramatically between excursion types but shearwaters traveling to oceanic waters made more dives per trip. The number of landings on the sea surface (279 ± 240 landings per trip) did not differ between excursion types, but was positively correlated with trip duration. This study illuminates the wide-ranging habitat use of sooty shearwaters from different breeding colonies. Our results also indicate that shearwaters from different colonies, separated by considerable distances, can overlap at sea. This study also highlights the specific behaviours of a small seabird using novel data loggers.

POPULATION TRENDS IN BREEDING SEABIRDS AT SAINT LAZARIA ISLAND, ALASKA

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As part of the seabird monitoring program on the Alaska Maritime National Wildlife Refuge, seabirds have been studied at St. Lazaria Island, in central southeast Alaska, since 1994. Species studied represent a range of feeding guilds including surface-feeding planktivores and diving piscivores. We evaluated the population trends for six species, recording increases for planktivores (i.e., storm-petrels – *Oceanodroma furcata* and *O. leucorhoa*) but declines or no trends for various species of piscivores (e.g., murre – *Uria aalge* and *U. lomvia*, tufted puffin – *Fratercula cirrhata*, and Rhinoceros Auklet – *Cerorhinca monocerata*). An evaluation of late spring sea surface temperature anomalies over the period indicated relatively stable temperature conditions. Indices to local forage fish abundance were also investigated to evaluate relationships with population trends.

CHARACTERISTICS OF THE SEABIRD AVIFAUNA OF ONE OF THE MOST IMPORTANT BRACKISH WATER SEAS – THE BALTIC SEA

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The Baltic Sea is a large shallow sea in northeastern Europe. The only connection to the adjacent North Sea – and the NE Atlantic – is the narrow and shallow Kattegat, an effective barrier preventing the ocean water from freely flowing into the Baltic Sea. Therefore, the Baltic Sea is a brackish water body, and this brackish character strongly influences its seabird community. While pelagic species like Northern Fulmars (*Fulmarus glacialis*) or Northern Gannets (*Sula bassana*) are only rare visitors from the adjacent North Sea, the avifauna is dominated by seaducks, grebes, divers and gulls. For many species, the Baltic Sea is one of the most important resting areas in the Western Palearctic. In the

German Baltic Sea, 38 seabird and waterbird species are regularly found in coastal or offshore waters. They exhibit spatial and temporal differences in distribution and different requirements concerning habitat selection. While huge amounts of Long-tailed Ducks (*Clangula hyemalis*) and White-winged Scoters (*Melanitta fusca*) overwinter in the German Baltic Sea, Common Scoters (*Melanitta nigra*) also exhibit an important summer and moulting concentration in the area. Great-Crested Grebes (*Podiceps cristatus*) and Red-breasted Mergansers (*Mergus serrator*) are restricted to coastal waters, while Red-necked Grebes (*Podiceps grisegena*) occur in Offshore areas. For Slavonian Grebes (*Podiceps auritus*), water depth as well as sediment type could be identified as important factors influencing habitat selection. As benthivorous feeders, seaducks are concentrated at coastal waters and offshore banks with low water depths. Gulls, on the other hand, are widely dispersed species, often associated with fishing vessels, like Herring (*Larus argentatus*) and Greater Black-backed Gulls (*Larus marinus*).

OUTREACH PROGRAM TO PREVENT NEW RAT INTRODUCTIONS TO ALASKAN ISLANDS

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The Alaska Maritime National Wildlife Refuge manages over 2500 islands, reefs and spires, totaling about 4.5 million acres and protecting significant wildlife areas. Rats, along with other invasive species, have devastated wildlife on several islands. In addition to restoration work, the Refuge has a program to prevent new introductions. These include: 1) Pribilof Islands defenses, 2) Shipwreck response to stop “rat spills”, 3) Outreach to ships to make them more rat free, and 4) Encouraging ports to control rats to reduce the potential for their spread. To accomplish such a broad approach we have attempted to form partnerships with other agencies, local governments, conservation organizations, and industry. We developed a traveling display and brochures which have now become a part of our outreach program. It is designed to communicate primarily with ship owners to encourage precautions to be rodent free, thus lessening the chances of rodents being introduced to new islands through ports or shipwrecks. Rodent prevention kits and outreach has occurred to several hundred ships, primarily those traveling to the Pribilof Islands. Efforts to control rats at ports, with a special component for docks where rats would board ships have been started. Preventing new introductions we hope will be an effective conservation strategy.

COOPORATIVE SEABIRD CONSERVATION BETWEEN THE ALASKA MARITIME NWR, USA AND THE COMMANDER ISLANDS NATURE RESERVE, RUSSIA.

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Russia and the United States surround the Bering Sea, so it is natural that we would share interest in biological monitoring and management of our wildlife resources. With World Wildlife Fund sponsorship, the Commander Islands Nature Biosphere Reserve (CIBR) and the Alaska Maritime National Wildlife Refuge (AMNWR) have jointly developed plans for joint work on conservation and a sister refuge/reserve relationship. Discussions to date include 1) coordinating seabird monitoring and reporting; 2) invasive species management, 3) outreach and education, and 4) oil/“rat spill” response. Plans are developing to have Russian researchers participate at AMNWR annual monitoring sites to exchange technical expertise with the hope that comparable annual monitoring can develop on the CIBR and AMNWR sites. Plans for collection and analysis of seabird eggs for contaminate have been initiated on both sides. Beach bird surveys have now started at Bering Island and Alaskan sites using the Coastal Observation and Seabird Survey Team (COASST) protocols. Information exchange and outreach regarding invasive rodent programs have been initiated, including plans for rodent prevention kits being distributed on both sides are progressing. Response to marine disasters, such as oil and rat

spills, need to be much further explored. The AMNWR and CIBR hope these efforts will help more fully reflect a truer picture of the Bering Sea ecosystem and improved conservation strategies.

PARTITIONING PELAGIC PAELLA; THE FEEDING STRATEGIES AND DIETS OF AVIFAUNA OF THE EASTERN TROPICAL PACIFIC.

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During 1983 - 1991, we studied the feeding ecology of the marine avifauna of the eastern tropical Pacific Ocean (ETP). We identified a total of 10,374 prey items from 2,076 specimens of the 30 predominant species of the ETP. Based on behavior observed during at-sea surveys, the ETP avifauna sorted into two groups: 15 species that generally fed solitarily and 15 species that generally fed in multispecies flocks. The avifauna used a combination of four feeding strategies: 1) association with surface-feeding piscine predators (primarily tuna); 2) nocturnal feeding on diel, vertically migrating mesopelagic prey; 3) scavenging dead cephalopods; and 4) feeding diurnally on non-cephalopod invertebrates and fish eggs. The solitary group obtained most of its prey while feeding nocturnally, primarily on mesopelagic fishes, and flocking species fed primarily on flyingfish and squid caught when feeding diurnally in association with tuna. Diet partitioning was evident within each feeding group. Using generalized additive models and at-sea survey data, we estimated that the ETP avifauna consisted of about 32 million birds (range 28.5 - 35 million). They consumed about 1,700 mt of food per day. 78% of prey were obtained when feeding in association with aquatic predators, 14% when feeding nocturnally, and 4%, each, when scavenging dead cephalopods or feeding diurnally on non-cephalopod invertebrates and fish eggs. This paper will be presented in honor of Larry Spear who passed away while completing the monograph 'Foraging Dynamics of Seabirds in the Eastern Tropical Pacific Ocean' that this presentation is based on.

AGE-RELATED CHANGES IN STRESS PHYSIOLOGY IN LAYSAN ALBATROSS (*PHOEBASTRIA IMMUTABILIS*)

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Increasing glucocorticoids is one of the primary responses to acute stress. There is recent evidence, however, of rapid decline in corticosteroid binding globulins in some species. It is unclear what role binding globulins play in mediating tissue availability; if the free hormone hypothesis is correct, then rapid declines in CBG may significantly increase glucocorticoid access to tissues, and therefore behavioral or physiological responses to stress. We found that CBG capacity in Laysan Albatross (*Phoebastria immutabilis*) changes within 60min acute stress, much more quickly than previously measured. We propose two hypotheses that could explain this rapid CBG response at the individual level. (1) Longevity: In long-lived species, younger birds have greater reproductive value. As such, they may be more likely to abandon the current reproductive effort in favor of self-maintenance. This hypothesis predicts that younger birds would show a greater decline in CBG during stress. (2) Body Condition: Albatross are capital breeders and rely heavily on body condition for reproductive energy. Capital breeders can retain large energy stores and it may be beneficial for them to respond to critically declining condition, not simply current food availability. This hypothesis predicts that individuals in lower condition would show a greater decline in CBG during acute stress. In albatross, CBG decline correlates with age ($p=0.013$), and this change appears to drive a significant relationship between free corticosterone and age ($p=0.015$): younger birds exhibit greater decline in CBG and greater increase in corticosterone during acute stress. We do not detect any relationship with body condition.

FORAGING BEHAVIOUR OF THE GALAPAGOS PENGUIN, *SPHENISCUS MENDICULUS*: IMPLICATION FOR CONSERVATION

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The endangered Galápagos Penguin (*Spheniscus mendiculus*) is endemic to the Galápagos archipelago with a population of less than 2000 individuals. In 2004 and 2005, we studied the movements and diving behaviour of foraging Galápagos penguins to examine space utilisation and whether area-use might indicate why the population is so small and spatially restricted. Twenty-three adult penguins were fitted with GPS-Temperature Depth recorders at the penguin's main nesting sites. Birds moved between 1.0 and 23.6 km (mean = 5.2 ± 4.8 km) from the nest along the coast, and concentrated their foraging effort in a strip of sea up to only 1.1 km from the coast. There was a significant latitudinal gradient with penguins in southern locations foraging closer to the shore and travelled further away from the nest. Foraging trips lasted a mean of 8.4 ± 2.0 hours. Although the deepest dive was 52.1 m, birds spent on average 90% of their time underwater at depths of less than 6 m. Both foraging ranges and dive depths were below those predicted from allometric regressions from other penguin species. The Galápagos penguin exploits a maximum volume of water of $< 1.4 \text{ km}^3$, which is almost 90 times less than that predicted for its mass, and thus utilises only a small portion of the total potentially available upwelling area within the Galápagos archipelago. These results are put into context with current conservation and management issues in the Galápagos Marine Reserve.

USING FIRST-PASSAGE TIME TO ANALYZE TRACKING DATA AND QUANTIFY THE SPATIAL SCALE OF INTERACTION BETWEEN SEABIRDS AND THEIR ENVIRONMENT

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An important component of habitat analysis is understanding how and at what spatial scale an animal is interacting with the environment. An analytical technique proposed to address these concerns in analyzing continuous tracking data is first-passage time (FPT). FPT analysis can identify where the animal's path becomes sinuous (indicating an area-restricted search pattern), thereby signifying potential foraging vs. transitory movements and, more importantly, at what spatial scale area-restricted search is occurring. I tested the application of FPT analysis by integrating visual tracking of black-legged kittiwakes (*Rissa tridactyla*) with aerial surveys of surface-schooling forage fishes and satellite tracking of short-tailed albatrosses (*Phoebastria albatrus*) with remotely sensed oceanographic data.

Among kittiwakes, area-restricted search occurred at a greater spatial scale (> 2 km) when foraging on primarily large, adult capelin (*Millotus villosus*) schools vs. ~ 0.6 km when foraging on primarily juvenile herring (*Clupea pallasii*) and Pacific sand lance (*Ammodytes hexapterus*). For short-tailed albatrosses, the scale of area-restricted search (70 km) was an order of magnitude larger than that of kittiwakes, and the spatial scale identified by FPT offered improved fit of habitat use models. Observational data from kittiwake tracking confirmed that FPT accurately identified regions of greater feeding activity along the movement path. Furthermore, I developed a sub-sampling algorithm for FPT (or any related technique) that permits modeling habitat use as a continuous process along a movement path. FPT proved successful for analyzing seabird tracking data and identifying the appropriate spatial scale(s) for quantifying their response to marine habitats.

CUTE DECOYS, AWESOME MUSIC, AND HOT WHEELS: ATTRACTING DOUBLE-CRESTED CORMORANTS AWAY FROM THE WORLD'S LARGEST COLONY.

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The colony of Double-crested Cormorants (*Phalacrocorax auritus albociliatus*) on East Sand Island (ESI) in the Columbia River estuary has grown from about 100 breeding pairs in 1989 to over 13,700 pairs in 2006, the largest-known breeding colony for the species. Fisheries managers are increasingly concerned about the impact of cormorant predation on ESA-listed juvenile salmonids in the estuary; concerns which may result in population control measures. Because the ESI colony represents as much as 50% of the *albociliatus* population, efforts to redistribute part of the ESI colony to alternative colony sites may be more appropriate than control. We tested potential methods for relocating part of the ESI colony using social attraction (decoys and audio playback systems) and habitat enhancement (sticks in old truck tires). We compared the efficacy of three types of artificial satellite colonies on ESI: 1) social attraction and tires on the ground, 2) social attraction and tires on elevated platforms, and 3) tires only on elevated platforms. The ground colonies were occupied first and had the highest density of active nests. Artificial colonies were also created on Rice Island (26 km upriver from ESI) and Miller Sands Spit (34 km upriver from ESI). Nesting cormorants were attracted and chicks successfully fledged at both artificial colonies, the first time that cormorants have nested successfully at artificial colonies on islands other than ESI. These results suggest that social attraction/habitat enhancement may be an effective technique for relocating part of the ESI cormorant colony and reducing its size.

SEABIRD-SOCKEYE SALMON CO-VARIATION IN THE EASTERN BERING SEA: FROM ECOSYSTEM INDICATORS TO SALMONID PREDICTORS?

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Piscivorous seabirds (*Rissa* spp. and *Uria* spp.) and sockeye salmon (*Onchorhynchus nerka*) of the eastern Bering Sea share similarities in their trophic ecology. We tested the role of seabirds as indicators of the food web conditions that may affect sockeye salmon survival at sea by investigating co-variation between seabirds breeding on the Pribilof Islands and returns of Bristol Bay sockeye at lags of up to 5 years. Seabird phenology (hatching dates of eggs) and productivity (number of young raised to independence per breeding pair), which vary in relation to climate variability (Byrd et al. in press, DSR II), were inversely and positively related, respectively, with sockeye returns, with the strongest co-variation found 2, 3, and 4 years before sockeye returns. Detrended breeding phenology of Red-legged Kittiwakes (*Rissa brevirostris*) on Saint Paul Island explained 50% of the sockeye returns with a 3 year lead. Coupling kittiwake phenology with existing annual predictions for Bristol Bay salmon improved forecast "skill" (i.e., increased R² value, simplified models). The most parsimonious explanation is that both the birds and salmon are responding to changes in climate via prey availability and/or quality, a "bottom-up" effect. The co-variation between seabird breeding parameters and sockeye returns supports the hypothesis that variation in seabird breeding parameters index food web conditions that also affects salmon survival at sea. This study demonstrates that seabirds can be used to both understand current ecosystem conditions and suggests a potential role for seabirds in forecasting commercially-valuable fisheries.

MESO-MARINE ECOSYSTEMS OF THE NORTH PACIFIC: SEASONAL AND INTERANNUAL VARIABILITY.

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We studied physical and biological variability across the sub-arctic North Pacific Ocean (along a 7,500 km transect from British Columbia, Canada, to Hokkaido, Japan) to test the hypothesis that “eco-regions” of the North Pacific are persistent between seasons and years. Plankton samples were collected with a Continuous Plankton Recorder (CPR) while an observer (MH) recorded marine birds and mammals. Physical oceanographic properties were measured using data loggers and XBTs. Temperature and chlorophyll *a* concentrations were obtained from satellite imagery. Using multi-dimensional clustering of physics, plankton and top predator data from June 2002, we identified 10 distinct North Pacific biological communities (or eco-regions) which we term “meso-marine ecosystems” (MMEs). MMEs have clear bathymetric and boundary current associations (Batten et al. 2006, DSR II 53:270-290). Using data from all years (2002-2005), we now investigate the temporal persistence of MMEs over 4 years and 3 seasons (spring, summer, fall). Eco-regional boundaries were persistent between years but varied by season due to migration. Regular monitoring of MMEs, including dynamic changes in plankton and predator communities, will enhance our ability to detect the ecosystem fluctuations that affect fish and other species, thereby promoting an ecosystem-approach to ocean resource management.

TESTING THE CRITERIA FOR PARAPATRIC SPECIATION USING TWO SPECIES OF PACIFIC SEABIRD: BLUE-FOOTED AND PERUVIAN BOOBIES

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Theoretically, strong selection combined with restricted dispersal can prevent gene flow and generate genetic differentiation between populations. If reproductive barriers arise as a result of genetic drift or selection between the populations, speciation may occur. Such speciation is described by the *stepping-stone model of parapatric speciation*. Parapatric speciation is a plausible mechanism of speciation and one that may occur frequently in nature, but convincingly demonstrating its occurrence is difficult. Demonstration of parapatric speciation requires three lines of evidence: post-zygotic isolation, a primary contact zone at an ecotone, and non-congruent clines for multiple traits. Several seabird species appear to have arisen via parapatric speciation. Blue-footed and Peruvian boobies (*Sula nebouxii* and *variegata*) breed along the western coast of South America and their ranges overlap where the Humboldt Current meets the Equatorial Counter-current in northern South America. They are recently diverged (~0.2mya) sister species with abutting ranges. As such, these species have the biogeographic signature of parapatric speciation. We are analyzing mtDNA and microsatellite variation from throughout the range of these species to test for parapatric speciation. Specifically we are measuring the extent of nuclear and mitochondrial introgression to test for post-zygotic isolation; determining whether the zone of contact is primary or secondary using statistical phylogeography; and testing for clinal overlap among multiple genes. Critically examining whether parapatric speciation has resulted in these two species will add to our current understanding of the mechanisms of speciation and the evolution of Pacific seabirds.

OPTIMAL DIVING STRATEGIES IN COMMON GUILLEMOTS AND RAZORBILLS: RESPONSES TO VARIABLE FEEDING CONDITIONS

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Common guillemots (*Uria aalge*) and razorbills (*Alca torda*) occur and breed sympatrically around the Isle of May, Scotland, UK but provision their chicks on different prey items and exhibit very different diving patterns. An optimal rate-maximising dive model was used to test the assumption that both species dived optimally for their given prey resources. Temporal variation in the quality of this resource was then investigated for both species in relation to prey types and rate of chick provisioning, chick productivity, and foraging locations and behaviour at sea. The prediction of optimal foraging was upheld for both species through frequency of dives over depths matching areas greatest profitability. There was also evidence for variation in prey patch quality between years and diurnally, which was best explained through relationships to chick feeding rates and prey behaviour; types and sizes of prey delivered had no correlation to patch quality. Razorbill chick success was higher when patch qualities were higher and both species showed similar fluctuations over years, suggesting that both were affected by similar processes. It is also suggested that the differing foraging tactics of these closely related alcid species may have evolved through a need to minimise resource competition, with each possessing the necessary traits to exploit particular prey. In light of a changing marine environment, the response of these top-predators to changes in prey patches may vary with the most flexible species able to make use of lower quality resources and raise more offspring when conditions are not favourable.

ANIMAL TRACKING: FROM RAW DATA TO COMPREHENSIVE INFORMATION.

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Tracking seabirds at sea is crucial for understanding of individual habitat choice, and foraging strategy. All tracking techniques have limitations. Therefore, data pre-processing is always necessary before starting any analysis, especially to deal with uneven sampling and spatial error. Further, analysis of hierarchical habitat use and spatial and temporal scale utilization is generally a primary concern, but the way to do so is often a problematic matter. Here, we overview problems and solutions, and we introduce some additional methodological tools to first deal with raw track data uncertainty and second analyze spatial scale utilization. Methodological tools include newly developed modeling reconstruction of tracking data, fractal analysis and kernel analysis. Modeling data using correlated random walk principles is proposed here as a conceptually simple way of using all information contained in the data thus avoiding the classical loss of information through filtering (i.e. deleting data). Then, determining the area restricted search (ARS) zones in a track can be done using a fractal analysis method, which increases the precision for the automatic determination of small scale ARS in an individual manner. This is a nice addition to the existing first passage time concepts. Finally, we show that a kernel analysis applied to individual tracks can be used as a tool to break down space and time utilization in standard units, which can be then compared between groups.

SEABIRD TISSUE ARCHIVAL AND MONITORING PROJECT (STAMP): 1999-FUTURE RESEARCH.

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The Seabird Tissue Archival and Monitoring Project (STAMP) began in 1999 as a co-operative program among the US Fish and Wildlife Service, the US Geological Survey, and the National Institute of Standards and Technology to collect, cryogenically store (on the decadal scale), and analyze seabird tissues (including eggs) for chemical contaminants (e.g., polychlorinated biphenyls [PCBs], organochlorine pesticides [e.g., DDTs and chlordanes], polybrominated diphenyl ethers [PBDEs], and metals [e.g. mercury, methylmercury, and butyltins]). The Bureau of Indian Affairs later became a STAMP partner. Since 1999, 984 egg clutches have been collected and banked from 5 Alaskan species (common and thick-billed murres [*Uria aalge* and *U. lomvia*], black-legged kittiwakes [*Rissa tridactyla*], and glaucous and glaucous-winged gulls [*Larus hyperboreus* and *L. glaucescens*]). A brief overview of the results revealing geographical trends (Gulf of Alaska generally has higher contaminants than Bering Sea), species differences (between the murre species and between murres and gulls), and temporal changes (variable among colonies) will be presented and future plans discussed. STAMP has recently expanded egg collections to Tatoosh Island, WA and would like to include additional geographical expansion. Potential discussion points include: Where should STAMP be focusing its attention, what species and tissues should be sampled, how often and how many samples, and are there other analyses that should be performed?

MODELING PREY CONSUMPTION FOR COMMON MURRE CHICKS (*URIA AALGE*) AT A COLONY IN CENTRAL CALIFORNIA: EFFECTS OF CHICK AGE AND ENVIRONMENTAL VARIATION.

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In order to effectively manage fishery resources we must develop an understanding of the “supply-side” dynamics for ecologically dependent consumers and how energy requirements change in response to environmental variability and population dynamics. We examined the prey requirements of Common Murre (*Uria aalge*) chicks at Southeast Farallon Island, CA from 1986 to 2006, a period of considerable population growth and environmental fluctuation. Diet composition and provisioning rates were determined by observing prey deliveries to dependent chicks. We estimated prey size in relation to adult bill length and calculated prey mass using length to weight regression equations derived for each prey species observed. We then estimated total biomass consumed by combining diet data, feeding rates, breeding performance, population size, and chick age in a prey consumption model. Provisioning rates and prey size both had positive non-linear relationships to chick age in most years. Both parameters increased with chick age until approximately 7 days old, then became essentially constant except for a reduction in provisioning rate as chicks approach fledging age. Total biomass of forage fish and squid consumed by the chick population exhibited considerable interannual variation, with estimates ranging from 4 metric tons in 1998 to almost 20 metric tons in 2004. The most influential parameters in our prey consumption model were population size, hatching success, and proportion of chicks surviving to fledging age. Prey consumption was reduced in 1998, 2003, 2005 and 2006 and was contrary to population trends. Reduced prey consumption in these years was likely a result of unfavorable environmental conditions and reduced prey resources.

MICROHABITAT USE AND PREY CAPTURE OF A BOTTOM FEEDING TOP PREDATOR, EUROPEAN SHAG, SHOWN BY CAMERA LOGGERS.

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Studies of at sea habitat use are essential for understanding the role of seabirds in marine ecosystem.

However, until recently relationships between foraging and habitat usage were only possible at a coarse scale. We used miniaturised bird-borne digital still camera loggers to obtain high quality images of foraging habitat used by European shags (*Phalacrocorax aristotelis*). Underwater images revealed that shags fed benthically but that foraging behaviour and prey taken varied markedly between habitats. In rocky habitat birds foraged solitarily, over wide range of depths (10 – 40 m) and traveled along the bottom while searching for their main prey butterflyfish (*Pholis gunnellus*). In contrast, shags using sandy habitat frequently fed with conspecifics, foraged over a narrow depth range (25-35 m) and spend the bottom phase of dive probing into the sand with their bill, presumably to catch lesser sandlance (*Ammodytes marinus*) the major prey item in the diet. Data from individual birds showed that each bird used both of rocky and sandy habitats within a day.

USING AIR PHOTOS TO INTERPRET QUALITY OF MARBLED MURRELET NESTING HABITAT IN SOUTH COASTAL BRITISH COLUMBIA

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Using air photos to identify Marbled Murrelet (*Brachyramphus marmoratus*) nesting habitat is a standard method applied in British Columbia to evaluate occurrence and quality of nesting habitat for management. We examined both the effectiveness of the habitat quality classification method and the potential role of air photo interpreted habitat variables for describing nesting habitat selectivity of murrelets in forests >140-years old. For testing, we used a sample of 118 nest sites (previously located using telemetry by SFU, 1998 – 2002) and 157 random sites in two study areas on the Sunshine Coast and one study area in Clayoquot Sound. Murrelets selected nest patches non-randomly with respect to air photo interpreted habitat variables, but selectivity varied between the two study regions. Generally, nest patches had taller and larger trees, more complex forest structure, and were located at lower meso slope positions near large gaps or nearby edges. Murrelets selected for nesting sites ranked Very High and High by the air photo method, avoided sites ranked Low or Very Low, while use of Moderate sites was proportionate to availability. We discuss how the classification may be improved and integrated into management planning.

STANDARDISED METHODS FOR SEABIRD SURVEY AT SEA FROM SHIPS IN EUROPE

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The first successful programme for survey of seabird distribution in northwest European seas started in 1979 in the UK sector of the North Sea. The key to the project's success was computerization of sightings and effort data. Surveys extended to wider European seas, and are carried out by organizations in fifteen countries, all using broadly compatible survey methods. Harmonization of survey methods among different groups began in earnest with the formation of the European Seabirds at Sea Co-ordinating Group (ESAS) in 1990. ESAS introduced minimum standards for survey techniques, coding and storage of data and for training. The minimum standard for ship-based survey is a strip transect method using snapshot counts for flying birds. The addition of distance data for birds on the sea allows these surveys to be treated as line transects and are compatible with distance analysis methods. A more recent addition includes detailed behavioural observations. Standardization of methods resulted in a single database of European surveys, allowing considerable synergy among ESAS partners, and the creation of a number of atlases of seabird distribution, and provision of data for

nature conservation purposes and fishery management. Setting standards for training by ESAS have helped to raise standards of survey work and data interpretation for environmental impact assessments.

FORAGING STRATEGIES OF SEABIRDS IN RELATION TO ENVIRONMENTAL CONDITIONS

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Understanding the rules governing foraging in a patchy environment is fundamental for developing realistic models of how animals behave in the wild and how they will respond to environmental changes. It is generally assumed that seabirds are foraging for unpredictable and patchy resources and that they should adjust their movements at various scale in response to prey distribution and prey encounter, for example by the use of Area Restricted Search (ARS). By using tracking studies of southern and tropical pelagic seabirds (mainly albatrosses, frigatebirds and boobies) I will address some questions about how seabirds forage in response to environmental conditions. In particular 1) are seabirds foraging for unpredictable resources, 2) do seabirds use systematically ARS and at which scale and 3) do they increase turning rate when prey have been encountered? Based on tracking studies it appears that the environment is less predictable in tropic than in temperate or polar zones, that predictability is high at large and meso scales, but at smaller scales it differs extensively according to the type of habitat. Most seabirds use ARS behaviour but the size of the ARS zone is variable according to the habitat used and the species. By combining GPS loggers with devices measuring prey capture I show that contrary to predictions in general birds do not show strong response to prey capture. The knowledge of the environment acquired over long periods in these long-lived animals is a major factor influencing foraging strategies.

NEW DEVELOPMENTS IN TRACKING LARGE AND SMALL SEABIRDS.

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BI-MODAL FORAGING STRATEGY IN A NORTHERN HEMISPHERE ALCID, THE LITTLE AUK (*Alle alle*).

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A dual trip time foraging strategy has previously been described for several species of procellariiformes of the southern hemisphere as a consequence of productive feeding grounds too distant from the colony to sufficiently provide the chick. Here, for the first time, we report a similar feeding trip pattern for an alcid of the northern hemisphere, the Little auk. Little auks were studied in two colonies on Spitsbergen, Norway in 2006 using radio transmitters and PIT tags, respectively. The analysis of a total of 700 feeding trips revealed a regular pattern that consisted of the alternation of long trips (lasting on average 16.9 and 23.7 h in colony A and B, respectively) and several consecutive short trips (mean duration 1.5 and 1.8 h). This general pattern was observed in all individuals studied and was consistent throughout the breeding period. However, the duration of long trips as well as the proportion of short trips increased with increasing chick age. Due to the species' high flight costs, Little auks are probably unable to provide their chick and maintain their own body condition by foraging only in high quality feeding areas outside the fjord systems. They may therefore have developed, as the procellariiformes of the southern oceans, a bimodal foraging strategy where they use

short trips to increase the feeding frequency to the chick by utilizing less profitable food sources close to the colony and long trips to replenish their own resources.

FISHES IN THE DIET OF BRANDT'S CORMORANTS (*PHALACROCORAX PENICILLATUS*) DURING THE NONBREEDING SEASON IN MOSS LANDING, CALIFORNIA

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Cormorants feed opportunistically; however, many of the fishes they eat rely on zooplankton as their food source. During years of decreased upwelling when zooplankton abundances are low, cormorants may be susceptible to starvation. In April and May 2005, Coastal Ocean Marine Bird and Mammal Education and Research Surveys (BeachCOMBERS) reported a seabird mortality event in Monterey Bay. Brandt's Cormorants (*Phalacrocorax penicillatus*) comprised 67% of the dead birds and all were classified as emaciated except one whose stomach contained northern anchovies (*Engraulis mordax*). A severe food limitation was suggested as the cause of the mortality event. We examined the diet of Brandt's Cormorants roosting on the south jetty of Moss Landing Harbor during the nonbreeding season (September to November 2005) using regurgitated pellets (n = 20). For each pellet, fish otoliths were extracted and identified to the lowest taxonomic level. We compared estimates of diet (2005) with diets determined by stomach content analysis from September 1974 to April 1975 (Baltz and Morejohn 1977). Percent similarity between the two studies was 40%. From 1974 to 1975, diet was 36% rockfishes (*Sebastes sp.*), 34% anchovy, 18% Pacific sanddab (*Citharichthys sordidus*), and 2% speckled sanddab (*Citharichthys stigmaeus*) compared with a diet in 2005 of 71% anchovy, 16% speckled sanddab, 1% Pacific sanddab, and 1% rockfishes. The observed differences in prey (decreased use of rockfishes and increased use of anchovy) may be a result of the oceanographic anomaly in 2005 or may indicate a more permanent change in the diet, warranting further investigation.

ADVANCING PROCELLARIID CONSERVATION: STRATEGIC ENGAGEMENT IN CRITICAL ISSUES FOR SEABIRDS BY THE WATERBIRD CONSERVATION COUNCIL.

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The Waterbird Conservation for the Americas initiative is guided by the Waterbird Conservation Council, a self-appointed, voluntary body made up of individuals committed to conservation of waterbirds and their habitats. The Council is charged with advancing the goals of the initiative and seeks proactive, collaborative approaches to address the most urgent large-scale waterbird conservation needs. To determine where and how this international partnership can best contribute to seabird conservation, the Council retained a team of University of Maryland Sustainable Development and Conservation Biology graduate students to perform a strategic situation assessment of the state of seabird conservation and the capacity of the Council and other existing institutions to address conservation needs. This assessment identified six critical issues underpinning seabird conservation: protection of important habitat; at-sea science; bycatch issues; oiling and pollution; climate change; and identification of additional emerging threats, and recommended specific thematic and species-focused projects allowing the Council to tangibly contribute to addressing one or more of these issues. Based on the status, distribution, and trans-equatorial movements of members of Procellariidae, and the lack of conservation attention currently focused on this family relative to others, the Council will build its efforts around shearwaters and petrels. Projects will take advantage of the expertise and experiences of the Council's network of biologists, administrators, and program coordinators from government, NGO and academic institutions throughout the Americas.

EFFECTS OF NUTRITIONAL RESTRICTION ON NITROGEN AND CARBON STABLE ISOTOPES IN GROWING SEABIRDS.

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Analysis of ¹²C/¹³C and ¹⁴N/¹⁵N stable isotopes in animal tissues provides a useful means of delineating dietary sources, determining trophic level of feeding and tracking migratory movements. However, when using stable isotopes as dietary tracers it is essential to consider effects of nutritional state on isotopic fractionation. While starvation is known to induce enrichment of ¹⁵N in body tissues, effects of moderate food restriction on isotope signatures have rarely been tested. We conducted two experiments to investigate effects of a 50-55% reduction in food intake on d¹⁵N and d¹³C values in blood cells and whole blood of tufted puffin (*Fratercula cirrhata*) chicks, a species that exhibits a variety of adaptive responses to nutritional deficits. We found that blood from puffin chicks fed *ad libitum* became enriched in ¹⁵N and ¹³C compared to food restricted chicks. Our results show that ¹⁵N enrichment is not always associated with food deprivation and argue growth affects diet-tissue fractionation of nitrogen stable isotopes ($\Delta^{15}\text{N}$). The decrease in d¹³C of whole blood and blood cells in restricted birds is likely due to incorporation of carbon from ¹³C depleted lipids into proteins. Nevertheless, estimated effect sizes of nutritional restriction on d¹⁵N and d¹³C values were relatively small in both experiments (d¹⁵N: 0.77‰ and 0.41‰, d¹³C: 0.20‰ and 0.25‰) compared to effects of ecological processes indicating physiological effects do not preclude use of carbon and nitrogen stable isotopes in studies of seabird ecology.

USING LINE TRANSECT SURVEYS TO DETERMINE NUMBERS AND DISTRIBUTION OF MARINE BIRDS IN THE INSHORE ENVIRONMENT.

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The Seabirds at Sea team of the UK's Joint Nature Conservation Committee are currently involved in assessing numbers and distributions of marine birds around the UK to determine whether certain inshore areas qualify for Special Protection Area status under the European Union Birds Directive. To do this, birds using the inshore environment are sampled using either boat-based surveys or aerial surveys in a way that allows us to use specific analysis techniques. Line-transect methods allow distance analyses, which model the decline in probability of detecting a bird with increasing distance from the transect line. This can produce total estimates of numbers of birds within a sampled area, corrected for the birds missed. Spatial analysis techniques model the spatial distribution of the data to predict densities, in areas that were not sampled, using interpolation. This gives a distribution pattern for the whole study area and indicates where birds are aggregated and the extent to which they occur offshore. These methods are explored using case studies from inshore environments around the UK.

HOW TO BE GOOD PARENTS: USING HAND-RAISED SEABIRDS TO PROVIDE INFORMATION ON THE DEVELOPMENT OF FLIGHT AND DIVING BEHAVIORS

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In recent years, we have learned a great deal about flying and diving behaviors in adult seabirds

using animal-borne data loggers. However, we know far less about these behaviors in juveniles and the ontogenic development of flight and diving, given the difficulty of performing repeated capture. To overcome this challenge, we hand-raised hatchling brown boobies (*Sula leucogaster*), known to have a long post-fledging care period. Once these boobies began to fly, they made round-trips between the sea and the nest and begged for food from us, the surrogate parents. During this period, the development of flight and diving behavior was recorded using data loggers at short sampling intervals (from 1/16 to 5 seconds). We used time-depth-acceleration data loggers to distinguish flapping and gliding flight and GPS data loggers to position birds. In addition, we attached data loggers to adult brown boobies breeding on Nakanokamishima Island, Japan, and compared the flight and diving performance with that of juveniles. As a result, juvenile brown boobies increased the proportion of time spent gliding during flight and the home range size increased with days after fledging. This indicates that brown boobies gradually acquire efficient flight skills during the post-fledging care period. Alternatively, the juveniles had relatively slow development of diving behavior after fledging. Therefore, we suggest that the slow development of diving behavior with ontogeny might be the proximate cause of the extended post-fledging care period in this species. We expect the combination of bio-logging and hand-raising of seabirds to be useful for assessing the ontogeny of diving behavior in these animals.

THE CENTRAL CALIFORNIA COAST SEABIRD HEALTH STUDY: USING A STANDARD APPROACH TO UNDERSTAND MORBIDITY AND MORTALITY FACTORS

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We summarize the post-mortem component of an ongoing study to identify and quantify species-specific morbidity and mortality factors affecting marine birds collected along the central California coast. 120 birds in 2005 and 327 birds in 2006 were collected through repeated beach surveys and from local rehabilitation centers. Using standardized necropsy protocols and ancillary diagnostics, causes of morbidity and mortality included malnutrition, infectious disease, oiling, and trauma. Malnutrition caused two significant die-offs involving Brandt's cormorants, Common murrelets, and auklets during May to July 2005 (n = 39) and a Red phalarope (*Phalaropus fulicaria*) wreck during November to January 2006 (n = 43). Throughout 2006, malnutrition continued as the main mortality factor for most resident seabird species, likely reflecting the regional persistent poor feeding conditions. Accordingly, in June 2006, a Brown pelican (*Pelecanus occidentalis*) wreck was likely a stochastic event associated with food availability and population dynamics. In contrast, in May 2006, another Brown pelican wreck was not a stochastic event, but was of a suspected infectious etiology. Several additional cases involved infectious diseases of bacterial, viral, fungal, and protozoal etiology. Infections either were opportunistic or the primary debilitating factor and in some cases, involved suspected or confirmed novel entities. Metazoan parasites usually were incidental; however, one Surf scoter (*Melanitta perspiculata*) died from severe intestinal acanthocephaliasis. Oiling was a minor (<5%) mortality factor, affecting mostly diving birds. Trauma was both natural (e.g., depredation) and human-related (e.g., fishery). Collaboration with rehabilitation centers, state and local agencies, and beach survey programs greatly contributes to our understanding of seabird morbidity and mortality.

POPULATION IMPACTS OF ENDANGERED SHORT-TAILED ALBATROSS BYCATCH IN THE ALASKAN TRAWL FISHERY

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We conducted a decision analysis that explores the effects of trawl-related fisheries mortality on achieving the population recovery goals for the U.S. federally-endangered short-tailed albatross (*Phoebastria albatrus*), proposed by the U.S. Fish and Wildlife Service. A population model was constructed and its parameters estimated by fitting it to counts of the numbers of albatross chicks and eggs at Torishima Island, Japan, where 83% of the world's population of this species is found. Bayesian inference was used to assign probabilities to alternative plausible rates of fishing mortality and to conduct population projections with different levels of trawl mortality to determine their effects on achieving the population recovery goals. The analyses of the impact of trawl mortality on the Torishima short-tailed albatross population suggests that exceeding the current expected incidental take in the Alaska groundfish trawl fishery, two in any five year period, by as much as a factor of 10 would have little impact on when the proposed recovery goals for the species are achieved. A quantitative approach that addresses uncertainty such as that outlined in this study could aid the process to evaluate allowable limits in light of species recovery goals by addressing both take limits and recovery goals within the same framework.

LAND-BASED SURVEYS OF THE VERY NEARSHORE AND WHAT A 29-MONTH TIME SERIES TELLS US ABOUT SEABIRDS NEAR THE MOUTH OF THE COLUMBIA RIVER

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In August of 2004, we initiated a fixed-location, land-based survey of seabirds on the southern Washington coast, ~ 5 km north of the mouth of the Columbia River. Surveys were performed at least monthly from a 59 m high cliff at the North Head Lighthouse, WA. Counts of all species sitting on the water were made once every half hour during all daylight hours with a 20X spotting scope. The scope was mounted at a fixed angle in the same position so that an identical area was surveyed each time. The area swept included the surf zone to ~1.4 km offshore within a 700 m wide band. Counts of all birds flying passing a fixed east-to-west line during a 5-minute period were conducted immediately after completing the survey of sitting birds. Flying counts extended from shore to ~2.5 km offshore and noted whether each bird crossed the line flying from south to north or north to south. Data provide documentation on transitions from summer communities dominated by common murre (*Uria aalge*), cormorants (*Phalacrocorax sp.*), summer gulls (*Larus sp.*), Caspian terns (*Sterna caspia*), and brown pelicans (*Pelecanus occidentalis*) to winter communities dominated by Western grebes (*Aechmophorus occidentalis*), winter gulls, and surf scoters (*Melanitta perspicillata*). The techniques we developed provide relatively low-cost seabird data in habitats and seasons not effectively surveyed by ships. Surveys also provide high-resolution temporal data appropriate to analyzing tidal, daily, monthly, seasonal, and interannual patterns in species abundance.

USE OF SEABIRD TRACKING INFORMATION TO IMPROVE ESTIMATES OF FISHERIES BYCATCH

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Seabird bycatch in fishing gear is a significant source of mortality, which has been invoked to explain the population declines of a number of albatross and petrel species. Understanding how seabird distributions overlap with fisheries is an important first step to estimate total fisheries mortality and to prioritize monitoring and research efforts to mitigate bycatch. We explored the potential of using bird satellite tracking information to improve our understanding of the factors contributing to bird mortality

in fisheries. We used satellite telemetry data of breeding Black-footed and Laysan Albatrosses (*Phoebastria nigripes*, *Ph. immutabilis*) tracked from Tern Island (French Frigate Shoals, NWHI) in 1998, and Hawaii-based longline fishery information collected by onboard observers in 1998. There was little spatial overlap between the kernel home-ranges of tracked individuals during the brooding season (January – February) and the longline fishery. However, kernel home-range estimates of both albatross species were important predictors of bycatch during the chick rearing period (March – June), when the birds ranged much farther from the colony. This demonstrates that using bird tracking data could improve the predictive ability of bycatch models and advance quantitative assessments of seabird mortality in fisheries. In addition to bird tracking information, we will undertake more extensive use of remotely sensed oceanographic data to characterize the habitats where birds forage, where fisheries operate, and where bycatch takes place.