

Pacific Seabird Group

Twenty-sixth Annual Meeting

24-28 February 1999

The Inn at Semi-Ah-Moo, near Blaine, Washington

Sponsors

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SCIENTIFIC PROGRAM

This year's meeting has 130 papers being presented — 103 oral presentations and 27 posters. To start the program PSG is honored to have Dr. John Warham here to present a plenary address "Petrel problems and puzzles." Dr. Warham is from the University of Canterbury in Christchurch, New Zealand. PSG will be presenting Dr. Warham with this year's PSG Lifetime Achievement Award.

Oral presentations will be given in the Blakely and Cypress rooms of the Semi-Ah-Moo Ballroom. With the exception of our plenary session, there will be 2 concurrent sessions throughout the meeting. All presentations, except symposia presentations, will be 15 minutes long.

PSG is pleased to present 2 symposia this year that address subjects of major concern to marine ornithologists, by-catch and climate change. Ed Melvin has organized "Seabird by-catch: trends, roadblocks and solutions," and Bill Sydeman has organized "Climate variability and seabird response." Both sessions feature a broad mixture of presentations from seabird biologists to fishermen, students to grand fromages, and locals to international attendees. We regret that time and scheduling constraints necessitated holding the symposia on the same day. Symposium presentations vary in length from 20 to 50 minutes.

INSTRUCTIONS TO AUTHORS

Oral Presentations

The slide preview room is located behind the PSG Registration table and will be open from 0800 to 1700 Thursday, Friday, and Saturday. There are a few extra carousels if you need one; however, we ask that they not be borrowed for more than a few hours. Meeting rooms are equipped with both overhead and slide projectors. Please provide your slides to the projectionist at least 15 minutes before the start of the session and pick them up immediately following your session. Please contact your session chair before the start of the session to introduce yourself and clarify name pronunciation. Because of the need to hold concurrent sessions, session chairs and presenters are asked to keep all presentations (including questions) to their allocated time — 15 minutes for general papers and 20 minutes for most symposia. To facilitate time-keeping, there will be a clock on the podium for you and a clock maintained by your session chair. Questions or comments about the scientific program should be directed to Ed Murphy or your session chair. Questions regarding audio/visual needs should be directed to Chris Thompson or your session chair.

Posters

Posters can be assembled starting at 0800 on Thursday and should be taken down by 1200 on Saturday. Bill Ritchie will assist you. Please put your poster in the numbered area that corresponds to the number next to your poster title in the Schedule of Events. Authors of posters should be standing by their posters (if not their conclusions) and available for discussion during the Poster Reception on Thursday from 1900 to 2100.

Abstracts

Because the meeting abstracts will be published in "Pacific Seabirds" and posted on the PSG web page, you can edit or update your abstract should you desire. Amended abstracts will be due to Danielle Prenzlou Escene absolutely no later than March 5, 1999. Abstracts should be submitted in one of the following ways: 1) e-mail the amended abstract in the body of an e-mail *and* snail mail a hard copy; 2) e-mail the amended abstract as a WordPerfect attachment; OR 3) for just minor edits or corrections, e-mail a description of the edits.

e-mail: danielle.prenzlou@wadnr.gov

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PAPER TITLES, AUTHORS AND ABSTRACTS

NOTE: Abstracts of presented papers are not for citation. Abstracts often differ from the material actually presented. Interested parties should contact the authors prior to any use of abstracts.

EL NIÑO 1997-98: SEABIRD RESPONSES FROM THE SOUTHERN CALIFORNIA CURRENT AND GULF OF CALIFORNIA

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El Niño 1997-98 caused significant effects on breeding and wintering seabirds of Baja California and Southern California. In 1998, there were about 1200 BRPE nest attempts in the Midriff of the Gulf of California compared to a long-term average of about 25,000 nests (<5% of normal); one nest produced young. BRCO, DCCO, and YFGU followed the same trends, but some did produce a few young (<5% of normal). BRPE and BRCO effort and productivity improved north from Baja California into California and in the La Paz area, but was still highly variable (<1% to <90% of normal). In the Southern California Bight (SCB), BRPE nesting effort in 1998 was <47% of 1997, but productivity (associated with chick mortality) in 1997 (as ENSO conditions set-in) was 0.3 YY/N, compared to 0.9 in 1998 (as ENSO subsided). Depressed nesting effort in the Gulf of California also occurred in BRBO, BFBO, LESP, BLSP, ELTE, ROTE, and HEEG; off western Baja California in ROTE, DCCO, and CATE; and in the SCB, also in BRCO and DCCO. At Rasa Island (where >95% of the species nests), numbers of territorial HEEG were not reduced, but the proportion of these potential breeders that laid eggs was reduced. Productivity was 0.01 YY/N compared to 0.47 in 6 previous, non-ENSO years. ELTE nesting in 1998

consisted of 180 nests compared to about 40,000 averaged over 9 previous years; but those few ELTE reproduced normally. YFGU were more dispersed and pelagic than expected and storm-petrels occurred at sea in much lower abundances than during non-ENSO periods. Resident seabirds such as BRPE and boobies also suffered elevated mortality in winter 1997-98; but mortality was much more pronounced in wintering species such as grebes and loons, and it extended into June 1998. Dying EAGR in the Gulf of California and off the Baja California west coast were emaciated. OSPR, a resident feeding on resident fish, was more successful; yet, still only about ½ of the original OSPR nesting attempts in Bahia de los Angeles were still occupied by May 1998, producing only 0.3 fledglings per nest attempt, the lowest level yet recorded. Overall, 1997-98 was the most extensive El Niño-related nesting failure in Baja California seabirds in 30+ years of detailed study.

ANOMALOUS WEATHER EVENTS IN THE SOUTHEASTERN BERING SEA: THE CONDITION OF SHORT-TAILED SHEARWATERS IN 1997 AND 1998

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Both 1997 and 1998 were marked by unusual weather conditions in the southeastern Bering Sea, however the patterns were strikingly different. In 1997, a high pressure anomaly occurred over the Bering Sea and resulted in low winds and few severe storms in June and July, an unusually warm mixed-layer in summer, and depletion of macronutrients to greater than 60-m depth. In 1998, a low pressure anomaly occurred over the same area which resulted in frequent spring storm events that lasted into late June, a delayed set-up of thermal stratification, and prolonged production in the water column. Lack of mixing, higher sea surface temperatures, and early cessation of production in 1997 may have contributed to the lack of available euphausiid prey to short-tailed shearwaters (*Puffinus tenuirostris*). The result was that hundreds of thousands of short-tailed shearwaters died in August and September 1997, apparently of starvation. In 1998, we observed lower overall body condition of short-tailed shearwaters compared to 1997, yet no large scale mortality event occurred. When adjusted for overall body size, net body mass, lipid mass, and pectoralis mass was lower in June 1998 than June 1997. Also, these measures were lower for shearwaters in the Bering Sea in September 1998 compared to September 1997. Between 1997 and 1998, we also observed a shift in the diet of shearwaters from primarily euphausiids, *Thysanoessa* spp., in September 1997, to fish, specifically, sandlance and age-0 pollock, in September 1998. We hypothesize that the availability of these alternative food sources in 1998 may have prevented the occurrence of another large scale mortality event.

HABITAT EVALUATION FOR MARBLED MURRELETS IN LARGE, CONTINUOUS FORESTS OF COASTAL BRITISH COLUMBIA

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In comparison to the USA, where Marbled Murrelet (*Brachyramphus marmoratus*) habitat is largely fragmented, much murrelet habitat in Canada is continuous and lies within pristine watersheds. Consequently, the delineation of distinct stands and the association of occupied

behaviours with specific forest types is difficult. New forest management that considers wildlife requirements relies on information on habitat suitability within large expanses of old-growth forest. These large, continuous forests necessitate a method of prioritisation which takes advantage of mapped information. Furthermore, the biases, unwanted variation, and technical difficulties in collecting adequate murrelet activity data caused us to emphasise vegetation sampling for our evaluation of habitat suitability.

Based on data collected during four years of Marbled Murrelet inventory by the Ministry of Environment, Lands, and Parks, we designed a habitat suitability index for the Marbled Murrelet as a tool for effective habitat evaluation. It allows a prioritisation of habitats based on mapped information, such as found on the digital Vegetation Resources Inventory maps recently completed in Clayoquot Sound, British Columbia. Our habitat suitability index is based on forest stand attributes (tree height, stand age, vertical composition, canopy closure and basal area) and spatial variables (altitude and distance from ocean). The index was used in conjunction with a Geographic Information System to rank and map habitats of importance to Marbled Murrelets in the Ursus watershed.

The results are clear, understandable maps which categorise habitat as either important, sub-optimal or unsuitable for Marbled Murrelets and can be used by conservation managers not intimately familiar with murrelet habitat requirements.

TROPICAL SEABIRD FORAGING ECOLOGY

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Tropical seabirds forage in waters low in productivity relative to most non-tropical systems. This has profound implications; most tropical species must range widely and all are confined to forage essentially in two dimensions. Foraging strategies reflect these constraints. The single most important foraging strategy for tropical seabirds is to feed in association with subsurface predators, primarily tunas. In the tropical Pacific, these feeding opportunities support, at least in part, a majority of species, probably a majority of individuals for some species, indirectly determine abundance and distribution, and provide a resource around which a complex community with a predictable structure is centered. Other foraging strategies include solitary feeding and scavenging; few species use these exclusively, and those that do are rare. Nocturnal feeding has been observed regularly in only one species; at least two others purported to be nocturnal feeders obtain mesopelagic prey during the day by associating with subsurface predators. Feeding in association with oceanographic features is important for non-tropical seabirds, but its significance in the tropics remains unknown. Important topics for future research include precise quantification of seabird dependence on tunas, on nocturnal feeding, and on oceanographic features as prey aggregating mechanisms, and investigation of scale-dependent patterns. Most importantly, we suggest that efforts be focused on re-establishing the former abundance and diversity of tropical seabird communities, catastrophically altered as a result of human colonization of islands. It is only with a somewhat intact and functioning community that we can pursue the answers to ecological questions.

EFFECT OF TRANSECT LENGTH ON ABILITY TO DETECT SEABIRD POPULATION TRENDS

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Accurate and robust detection of population trends is critical for understanding and interpreting seabird conservation priorities and effectiveness. At-sea population monitoring of Marbled Murrelets (*Brachyramphus marmoratus*) uses near-shore line or strip transects to estimate population density and infer population trends. While much attention has been given to placement of these transects, there has been little consideration of how transect length may affect ability to detect population trends. There is a trade-off between sample size and variance when using short or long transect lengths. The coefficient of variation (CV) is reduced with longer surveys because spatial variation is masked. Shorter surveys have higher CVs due to spatial variation but lower standard errors due to a larger sample size. The result is that either choice has a similar ability to detect trends for high population densities. However, Marbled Murrelet densities are often low, especially in California and Oregon. Shorter transects may therefore result in many segments with small numbers close or equal to zero. This decreases power to detect negative density trends over time. Additionally, line transect (Distance) sampling methods require a high number of detections per transect to calculate reliable detection curves. In areas of low to medium density, short transects with small numbers of birds will not generate reliable detection curves. Power to detect density trends for transects from 2 to 100 km in length illustrate these concepts and suggest that longer transects should be used for trend analysis. If data is collected in short transect lengths, it should be combined before trend analysis.

OCEAN CLIMATE CHANGES MISMATCH PREY AND BREEDING SEABIRD POPULATIONS

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Climate change has been linked to the advancement of warm temperatures in the spring. Here I report significantly earlier breeding of seabirds on the largest colony in Western Canada, Triangle Island from 1975-1998. The rate of timing advancement as gauged by hatch date is on the order of 1 d per year for Cassin's Auklet, Rhinoceros Auklet, and Tufted Puffin, but is close to 2 d per year for the Common Murre. Concurrently, the timing of the peak availability of the copepod *Neocalanus plumchrus* (the dominant form of zooplankton biomass for the subarctic North East Pacific) has advanced by almost 2 d per year since 1975. I propose that differences in the rates of seasonal advancement for seabird timing and zooplankton availability has created a mismatch in the timing of prey and predator populations. Moreover, this mismatch has likely contributed to an increase in the incidence of reproductive failure for the Cassin's Auklet, Rhinoceros Auklet and Tufted Puffin in recent years.

EFFECTS OF THE 1997-1998 EL NIÑO ON SEABIRDS BREEDING IN BRITISH COLUMBIA

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British Columbia has a diverse range of alcids breeding in three distinct oceanographic domains. We examined the breeding chronology, breeding propensity and productivity on five colonies in British Columbia where time series of at least three consecutive years were available. Numbers of breeding Cassin's Auklet on Triangle and Frederick Island were significantly reduced and timing was delayed. Nestling growth and breeding success was reduced on Triangle Island but not on Frederick Island. Breeding of Ancient Murrelets on Limestone Island began early, but was spread over a much longer period than usual. In addition, half of the burrows were deserted during incubation, far more than has been observed in previous years. The patterns of intercolony variation for timing of breeding and nestling growth were similar to previous years for Rhinoceros Auklets nesting on Triangle Island, Seabird Rocks and Sgan Gwaii. Tufted Puffins on Triangle Island commenced breeding significantly earlier than in any previous years but experienced reproductive failure similar to other recent years. The Common Murres on Triangle Island had similar timing of breeding and strong reproductive performance as in previous years in the 1990s. We will highlight the interspecific similarities and differences in the observed patterns of breeding and examine the short term variability in the context of large scale interdecadal oceanographic changes.

RHINOCEROS AUKLET EGG PREDATION BY A NATIVE POPULATION OF *PEROMYSCUS*

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Keen's Mice (*Peromyscus keeni*) are native to Triangle Island, western Canada's largest seabird colony. *Peromyscus* spp. have long been recognized as egg predators of passerines and other small birds, but artificial nest experiments have suggested that the size of larger eggs protects them from being eaten by small, gape-limited predators such as mice. Nevertheless, egg predation by *Peromyscus* has already been documented for two of the smaller alcids. Here we present the first observed instance of *Peromyscus* predation on Rhinoceros Auklet (*Cerorhinca monocerata*) eggs, with mice commonly opening and eating eggs of nearly twice their own mass. Rodent predation was the single greatest cause of Rhinoceros Auklet egg loss at Triangle Island in 1998, and was likely responsible for more loss than all other causes combined. In one study plot, rodent depredation occurred on as many as 34% of eggs. This high rate of predation may be related to temporary egg neglect by foraging parents. We speculate that egg depredation may increase in years of low marine productivity, when adults increase foraging time at sea.

CALICUM IN PENGUINS EGGS: DOES DIET MATTER?

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Magellanic penguins (*Spheniscus magellanicus*) produce eggs with thick shells and must mobilize calcium quickly for eggshell formation. Unlike birds that fly through the air, penguins

have solid bones and may be able to mobilize calcium from bones. However, use of bone calcium is likely to be costly, particularly in Magellanic penguins, a species in which females fast for several weeks after laying their eggs. Alternatively, diet adjustments may play a significant role in calcium availability. We tested this hypothesis by comparing the diet of Magellanic males and females prior to egg laying and by comparing the diet of females prior to and after egg laying. Early in the season, females were significantly more likely to have shells in their stomachs than males. Later in the season, shells were largely absent from the stomach contents of both sexes and there was no significant difference between the sexes in occurrence of shells in stomach contents. We conclude that ingesting shells may be one mechanism that females use to increase the availability of calcium for eggshell formation.

THE IMPACTS OF THE 1998 EL NIÑO-SOUTHERN OSCILLATION ON NEARSHORE COMMON MURRE COLONIES IN CENTRAL CALIFORNIA

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El Niño-Southern Oscillation (ESNO) events have been shown to have serious negative impacts to the breeding success of Common Murre colonies. The nearshore Common Murre colonies at Devil's Slide Rock, the Point Reyes Headlands, and Castle and Hurricane Point Rocks were variously affected by the 1998 ESNO event this year. These impacts ranged from irregular attendance, delayed onset of breeding, decreased number of breeding pairs, increased disturbance by California Sea Lions and increased predation. These events had differing impacts on the reproductive success of our monitored colonies. This is the first year that detailed impacts of an ESNO event was documented on these nearshore colonies. Our monitoring efforts revealed many insights into how the ESNO impacts nearshore colonies and our active restoration site at Devil's Slide Rock.

ON THE IMPORTANCE OF SMALL MAMMALS AS NEST PREDATORS OF MARBLED MURRELETS

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Arboreal rodents are known from the literature to be occasional predators of vertebrates. Recent work on the Olympic Peninsula, Washington has identified deer mice, Douglas' squirrels, and northern flying squirrels as potential nest predators of the marbled murrelet. More detailed investigation of this potential has begun to determine (1) if deer mice, Douglas' squirrels, and northern flying squirrels will attack murrelet-sized nestlings under natural conditions and (2) the influence of nestling size, egg size, and nutritional stress on the predatory behavior of wild-caught rodents. In captivity, deer mice and flying squirrels have been seen to prey upon eggs and nestlings. Both hunger and nestling size seem to influence predation by captive animals. Field

trials have verified that deer mice are predators of murrelet-sized nestlings in the wild. We monitored 22 artificial canopy nests containing nestling pigeons as surrogates for nestling murrelets. Nine nests were in place for 30 nights or until predation. Of these, 6 nests were depredated (2 by deer mice), and 3 nests were active for 30 nights without depredation. Nineteen neutral interactions with potential predators were recorded (7 flying squirrels, 6 deer mice, 1 Douglas' squirrel, 1 Townsend's chipmunk and 3 Stellar's jays). Data from captive and field trials will be presented, and preliminary trends discussed.

RESPONSES BY MARBLED MURRELETS, INLAND AND AT SEA, TO VARIATIONS IN NEARSHORE OCEAN TEMPERATURE IN BRITISH COLUMBIA

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Periodic warm-ocean episodes are known to have negative impacts on some seabirds in the Pacific Northwest. Effects on the threatened Marbled Murrelet are not known. I review the responses of the murrelet to variable nearshore temperatures for 1979 through 1998, which includes two strong ENSO events and a general warming trend. Data from systematic marine transects were available from seven sites in B.C., covering 4-8 years per site. There was considerable intra- and inter-seasonal variation in the densities of murrelets in these samples, with weak negative effects of warm seas at some sites. Surveys of murrelets at inland breeding habitats in the old-growth forests of Vancouver Island over 8 years showed significant effects of ocean temperature. Specifically, the mean frequency of occupied detections, a measure of near-nest flight behaviours, was strongly negatively correlated with nearshore ocean temperature. Although the link between occupied detections and nesting success is not clear, these results suggest that warm nearshore conditions inhibit breeding activity to some degree. Reduced prey availability in warm seas is a likely cause. This has important implications for conservation and monitoring of this species. Inland surveys of flight detections are often used to delineate and map suitable habitat for murrelets as part of logging plans, and could be seriously flawed if they sampled years with depressed activity. If murrelet breeding is inhibited by warm oceans then global warming, coupled with continued loss of nesting habitat in old-growth forests, is likely to lead to significant population declines.

MARBLED MURRELET RADIO TELEMETRY IN CENTRAL CALIFORNIA IN 1997 AND 1998: A REDUCED BREEDING EFFORT NOTED IN AN EL NIÑO YEAR

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In 1998 we radio marked 19 birds, all with brood patches indicating egg-laying. Sex ratio was 13 females:6 males (9 females:17 males in May/June 1997). Compared to 1997, radio-marked murrelets exhibited reduced breeding effort, especially relaying, based on several factors: 1) apparent reduction in prey abundance or availability due to El Niño conditions; 2) late arrival in Año Nuevo Bay; 3) no nests were found (five nests in 1997); 4) few birds were detected inland;

and 5) more birds foraged in kelp beds near Santa Cruz. A distinct weight gain was apparent from May-August 1997, but a slight decrease occurred in 1998. Five mortalities occurred in 1998 (two mortalities in 1997); one apparently the result of peregrine falcon predation, the remainder likely caused by a combination of factors. Necropsies were inconclusive but revealed a lack of cardiac and abdominal fat. Four signals were lost within nine days of deployment. Excluding these and known mortalities, mean tracking duration was 45 days. Two long distance movements 200 km south were documented on 18 June and 14 July.

POSSIBLE EFFECTS OF EL NIÑO ON BREEDING SEABIRDS IN ALASKA IN 1998

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Reproductive failures of seabirds, presumably due to shifts in prey distribution, have been documented during periods of unusually warm sea temperatures associated with El Niño Southern Oscillations. The most recent El Niño event in 1997 and 1998 was one of the largest recorded, and we were interested in trying to determine whether breeding seabirds in Alaska demonstrated a response. We examined selected parameters of breeding success for common species including: black-legged kittiwakes (*Rissa tridactyla*), murre (*Uria* spp.), rhinoceros auklets (*Cerorhinca monocerata*), and tufted puffins (*Fratercula cirrhata*) at breeding colonies throughout the state. The most obvious anomaly was that murre had below-average productivity in the western Gulf of Alaska and southeastern Bering Sea regions. We discuss this outcome, which was surprising because no such effect was seen for kittiwakes, frequently more sensitive to environmental perturbations than murre, at some of the colonies where murre failed. Furthermore, murre did not fail in southeastern Alaska or in some of the colonies in the central Gulf of Alaska, "upstream" of the colonies where low success was recorded.

USING MULTI-SCALE INVENTORY AND RESEARCH TO CONSERVE MARBLED MURRELETS IN CLAYOQUOT SOUND, BRITISH COLUMBIA

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Clayoquot Sound, Vancouver Island is an area of high profile forest conflicts which supports some of the largest concentrations of breeding Marbled Murrelets in North America. In 1994, the Province of British Columbia appointed an international Scientific Panel to make recommendations regarding forest management in Clayoquot Sound. The Scientific Panel made a strong recommendation that: "particular species known or suspected to be at risk are monitored and their habitats protected."

Our goal is to provide quantitative information on critical habitats for Marbled Murrelets in Clayoquot Sound. We gathered data at a full range of spatial scales over three years. Boat surveys were used to estimate numbers and marine distribution of murrelets, high frequency radar allowed us to count numbers of murrelets entering specific watersheds, standard audio-

visual surveys determined occupancy, vegetation surveys correlated activity with habitat parameters and tree-climbing determined nesting density.

Sea-surveys showed that there is significant variation in year to year numbers and distribution of Marbled Murrelets. Using sea survey and radar data we estimate the current population of Marbled Murrelets in Clayoquot Sound to be 6000-8000 birds. High radar detection numbers correlated with size of watershed and amount of remaining valley-bottom timber. We found that occupied detections significantly correlated with large (both tall and large diameter) moss-covered coniferous trees in low-elevation stands. A combination of ecosystem classification, three years of detection data and GIS mapping analyses was used to map habitats of importance. Tree-climbing of random trees with potential platforms demonstrated that Marbled Murrelets nest in very low densities (.18 - .28/ha) in the Ursus watershed. We continue to use this information in planning processes delineate important habitat and management zones for Marbled Murrelets in Clayoquot Sound, and other coastal areas of British Columbia.

SURVIVAL AND FECUNDITY OF MARBLED MURRELETS AT DESOLATION SOUND, B.C.

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A marked population of Marbled Murrelets (*Brachyramphus marmoratus*) has been studied in considerable detail since 1991 at Desolation Sound, British Columbia. During that time 1,154 birds have been caught using either a mist-netting or dip-netting technique and more than 100 birds have been recaptured at least once, with a recapture rate of 12.5%. Using CMR methodology on these data, we update our estimation of local annual adult survival of this population to the value of 8.848 (0.604 - 0.953) using the program MARK. This is close to the value predicted by Beissinger (1995) for Alcids laying a single egg and assuming an allometric relationship between survival and body size. Forty adult murrelets had radio transmitters applied to them in May and their subsequent movements noted for nesting activity. Ten of these did not nest, but 24 were followed to nests and 23 nests were found. Breeding success of this sample, the largest sample of active nests ever discovered in a single season in this species, was estimated at around 41%, with an overall fecundity (including the non-breeders) of 29%. There are however large error estimates in these values and larger samples are needed. Nevertheless these estimates provide initial data on which to begin population modeling.

EVALUATING THE MARBLED MURRELET SURVEY PROTOCOL WITH RADAR

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We compared concurrent radar and audio-visual observations during 82 mornings in 1997 and 1998 to help evaluate the Inland Forest Survey Protocol (IFSP) for Marbled Murrelets. Each morning, radar data were collected on all murrelet targets that passed over the area surrounding an audio-visual observer. For each observation, we determined whether radar, audio-visual observer, or both had detected the murrelet. We found that 21% of murrelet movements at

occupied stands occur before IFSP survey start time. Because of the dark conditions and because the birds that flew in early were silent, a very small proportion (6%) of these "early" birds were detected by the audio-visual observer. For the entire morning, observers conducting IFSP surveys missed an average of between 89 and 95% of the murrelets (depending on the method used to calculate the percentage). Because of the large within-site and among-site variation in the proportion of murrelets that were detected on IFSP surveys, we believe that it is inappropriate to use those percentages as a correction factor for IFSP counts. Some overestimation of the number of birds using a stand also was observed: 7% of the murrelets that were detected during IFSP surveys were not even using the stand that was being surveyed. Further, a minimum of 3% of detections was double-counted by audio-visual observers. We discuss the implications of our results for interpreting data collected using the Inland Forest Survey Protocol.

OFF THE HOOK? INITIATIVES AROUND THE WORLD TO REDUCE SEABIRD BY-CATCH BY LONGLINE FISHERIES

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Seabird by-catch by longline fisheries is of serious conservation concern to albatrosses and petrels, especially of the Southern and North Pacific Oceans. International initiatives to reduce seabird by-catch include the FAO International Plan of Action for Reducing Incidental Catch of Seabirds in Longline Fisheries, which will lead to National Plans of Actions and a postulated albatross Range State Agreement under the Bonn Convention on Migratory Species, being led by the Valdivia Group of Southern Hemisphere Countries for the Environment. Regionally, regulations of the Commissions for the Conservation of Antarctic Marine Living Resources and for the Conservation of Southern Bluefin Tuna have reduced seabird mortality. Nationally, Australia, Japan, New Zealand, South Africa and the USA have adopted mitigation regulations in some of their domestic longline fisheries. Priorities are the adoption of FAO National Plans of Actions by longlining nations; furthering the Bonn Convention initiative; monitoring seabird by-catch in domestic and high-seas longline fisheries, especially Asian, Latin American and pelagic tuna; and improving mitigation measures by commercial development of new line-weighting and under-water setting techniques. The Global Environmental Facility is a possible means of support for implementing effective mitigation measures in developing countries. Unsanctioned "pirate" longlining and its attendant high levels of seabird by-catch, especially in the Southern Ocean, remains one of the biggest problems to address.

MARINE POLLUTION: A SERIOUS PROBLEM FOR BREEDING ALBATROSS

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Dumping plastic at-sea has been prohibited by an international Convention, MARPOL Annex V (e.g., MARPOL is an acronym for Marine Pollution), for at least a decade, yet plastic ingestion by seabirds has increased and plastic debris continues to wash ashore on the Hawaiian Islands. Either there must be a large derelict floating mass of plastic that accumulated prior to the

enforcement of MARPOL Annex V, or people are still dumping garbage over the side of their vessels. If people are dumping fishing gear or light sticks at-sea, then according to the U.S. Coast Guard (USCG) this event is rarely witnessed. Without hard evidence, such as identifying marks to the origin of the plastic, it is difficult for USCG to issue MARPOL Annex V violations. Recently, concern has been expressed to the Western Pacific Regional Fishery Management Council regarding the numerous light sticks and cigarette lighters found in the remains of albatross chicks on the Northwestern Hawaiian Islands. Adult seabirds ingest plastic items while foraging for food at-sea and then inadvertently feed the plastic to their young. Albatrosses tend to follow ships, and as opportunistic foragers, they quickly learn that the ships can be a source of food. Plastic garbage lost intentionally or unintentionally from ships could easily be the source of their plastic in the marine environment. But as the sources for plastic pollution are varied and complex, understanding and identifying the origins of plastics is a first step to stopping the pollution.

A SEABIRD WORKSHOP: OVERCOMING ROADBLOCKS AND FINDING SOLUTIONS

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The Western Pacific Regional fishery Management Council sponsored a workshop to investigate how seabird mortality in the Hawaii-based domestic longline fishery is affecting the Black-footed Albatross (*Phoebastria nigripes*) population. Experts in seabird ecology, fisheries management and population modeling participated in the three-day workshop convened in the Council offices. Decades of seabird census and banding reports, plus seven years of Hawaii-based longline fishery data were supplied to the workshop participants. Analyses generated from the bird-banding data found that juvenile Black-footed Albatrosses were caught on longline more frequently than adult Black-footed Albatrosses. A series of simulations were conducted to investigate how population removals added onto baseline mortality would affect the sustainable population growth rates. These simulations generated some rather robust conclusions and initiated recommendations for Council consideration.

GENE FLOW AND POPULATION DIVERGENCE IN MURRES

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Discriminating among the four modes of speciation (allopatric, peripatric, sympatric and parapatric) when studying the evolutionary history of an organism can be difficult. In highly vagile seabirds such as murre, opportunities for classical allopatric divergence seem to be rare, and limited to a few glaciation events. Morphological investigations have led to the identification of many subspecies of murre, demonstrating that significant morphological variation exists among them, and that natural selection may be responsible for at least some of the differences. Both murre species are highly philopatric, although dispersal of birds to non-natal colonies is not as rare as once thought. We believe that many modes of speciation/divergence are responsible for the current genetic structure of murre. Philopatry, together with selection to adapt to local environmental conditions, may be resulting in parapatric divergence. Isolation in high northern

breeding grounds, coupled with nearby overwintering sites in polynyas may be resulting in peripatric differentiation. Allopatric divergence of murrelets has already been demonstrated: the Atlantic and Pacific populations of each species have clearly evolved in allopatry. Methods we are using include genomic microsatellite and intron assays, and sequencing of the mitochondrial control region. Other preliminary results will be presented at the meeting.

FEEDING ECOLOGY OF KITTLITZ'S MURRELET IN PRINCE WILLIAM SOUND, ALASKA

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We studied the feeding ecology of Kittlitz's (*Brachyramphus brevirostris*) Murrelet in Prince William Sound, Alaska, during the summers of 1996-1998 in relation to at-sea environmental characteristics and other attributes. We examined the effects of time of day (morning, afternoon), season, year, tidal stage (rising, falling), current strength (weak, moderate, strong), habitat type, water depth, distance from shore, distance from freshwater input, shoreline substrate, percent ice cover, water clarity, sea-surface temperature, sea-surface salinity, and survey type (nearshore, offshore) on whether or not birds were feeding. Of these variables, only time of day, year, habitat type, water depth, distance from freshwater input, and survey type were significant in affecting feeding frequency. Kittlitz's Murrelets primarily ate the common forage fishes that occurred in these glaciated fjords, although both the low number of birds seen with fishes and the cold environmental conditions in these bays in early summer suggest that they may be foraging extensively on pelagic invertebrates at that time. Both the species and mean sizes of fishes eaten by the Kittlitz's Murrelet in summer overlapped extensively with those of fishes eaten by the closely related Marbled Murrelet (*B. marmoratus*), which also is the species that the Kittlitz's Murrelet occurred most often with in mixed-species foraging flocks. Thus, the two species may compete for prey during the summer.

MARBLED MURRELETS CAN BE VOCALLY "FINGERPRINTED"

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We analysed the variability in the vocalisations of the Marbled Murrelet (*Brachyramphus marmoratus*) and tested if individuals could be recognized by their calls. A literature review revealed that essentially all seabird species showed vocal individuality. Vocalizations are usually essential in maintaining long-term pair bonds, so this universality was not surprising. Vocalisations of Marbled Murrelets have not been investigated in this capacity. We describe the murrelet's vocal repertoire of nine call types and two non-vocal sounds. Humans were able to visually discriminate the sound spectrograms of calls made by different birds. The calls were not highly stereotyped in successive renditions, but showed gradations. Graded vocalisations allow almost infinite variations in call types, but we recognized certain components (elements) of the calls that reoccurred in many call types. Elements were either strongly harmonic or tonal in nature. Call types were placed in call groups based on acoustic features, grading patterns, and contextual use. Vocal individuality was found in the *keheer* call, and the most individually

recognizable features were: call duration, and the frequencies and durations of the tonal portions of the call. Using these characters, a cluster analysis had 100% success in discriminating 8 individuals using 20 calls. This suggests that vocal fingerprinting is possible. Vocal recognition of individuals could help interpret the behaviours presently used in inland surveys for assessing presence and occupancy. It could also be used to improve population estimates within forest stands.

POTENTIAL NESTING HABITAT OF THE MARBLED MURRELET IN PRINCE WILLIAM SOUND, ALASKA, IN RELATION TO FORAGING AREA

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Marbled murrelets were injured or killed by oil contamination from the Exxon Valdez oil spill of 1989. Maintenance of nesting habitat areas through compatible land management may facilitate population recovery. This study identifies potential nesting habitat of the marbled murrelet in Prince William Sound by linking habitat models to geographic databases of vegetation and physical site characteristics (e.g., elevation, landform, climate). Three scenarios of nesting habitat are displayed: 1) high biomass forests with abundant mossy platforms on sites that are relatively protected from storms; 2) same as #1 except that forest sites in closer proximity to foraging area have higher potential than more distant areas; and 3) an expanded view of nesting habitat that includes ground and non-forest nesting. Areas identified as having a high probability of containing nesting habitat could become focal areas for adjusting management prescriptions to favor habitat maintenance.

CLIMATE CHANGE IN THE WESTERN ARCTIC SINCE THE "LITTLE ICE AGE" — EFFECTS ON PACIFIC SEABIRDS

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Since the end of the "Little Ice Age" in the last century, the earth has experienced a period of increasing atmospheric temperatures. Polar regions are the first to demonstrate the effects of global warming due to patterns of atmospheric circulation and the presence of snow and ice habitats that respond immediately to alterations in temperature. In the northern Pacific and adjacent Arctic Ocean large numbers of seabirds breed in regions where seasonal snow restricts access to nest sites and sea ice limits access to prey in the water column. Significant changes in the duration of seasonal snow and ice cover with increasing air temperature should reduce temporal restraints on breeding and migration and, theoretically, allow for population and range expansion.

Evidence for such changes comes primarily from northern Alaska and the adjacent Arctic Ocean. The snow-free period in northern Alaska has increased by >4 days per decade over the last 50 years allowing population expansion and increases for at least two alcid species. Predictably, subarctic populations are demonstrating few effects of changes in snow and ice cover. Any benefits that seabird populations experience from the reduction in the physical constraints of ice and snow may be reduced or negated by climate-driven oceanographic changes reducing prey

abundance or availability.

PIGEON GUILLEMOT RESTORATION RESEARCH AT THE ALASKA SEALIFE CENTER

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Pigeon Guillemot populations in Prince William Sound were affected by the Exxon Valdez Oils Spill and have failed to recover from declines occurring before and after the spill. Three factors have been proposed for the lack of recovery: (1) increased predation on eggs and chicks, (2) reduced prey quality associated with increased dependence on lower-quality nearshore demersal fish, (3) stress associated with exposure to residual oil.

In 1998 we initiated studies on the first two of these factors. We constructed nesting platforms with nest boxes and decoys at the SeaLife Center in Seward, Alaska and in Prince William Sound to examine the utility of man-made nest cavities in reducing nest predation. We also examined the effect of prey quality on chick growth and fledging by hatching eggs in captivity and raising chicks on three diet treatments (high, moderate, or low lipid). The captive-raised chicks were allowed to fledge into the wild from the SeaLife Center and subsequent resightings or recruitment at the nesting platforms could demonstrate the effect of pre-fledging diet on post-fledging survival, and the utility of captive rearing as a direct restoration technique. In 1999-2000, small numbers of chicks will be dosed with oil to allow identification of blood biomarkers of oil ingestion. A lack of prospectors at the nesting platforms in 1998 and decreased breeding birds at colonies used for egg procurement could indicate Pigeon Guillemot populations are depleted throughout the Gulf of Alaska.

PREDATION BY KEEN'S MICE ON SEABIRD EGGS: EVIDENCE FROM STABLE ISOTOPE ANALYSES

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Evaluating the consumption of seabird eggs by predators can be difficult. Eggshells do not preserve well in stomach acid and unless fresh, egg yolk and albumen can be almost impossible to identify a few hours following their consumption. However, stable isotopes were recently used to analyze diets of seabird predators on Langara Island. This successful application provided us with the opportunity to examine egg predation by endemic Keen's Mice (*Peromyscus keeni*) on Triangle Island, British Columbia. We examined stable-carbon ($\delta^{13}\text{C}$) and nitrogen ($\delta^{15}\text{N}$) isotope composition in muscle and liver tissues of mice, abandoned eggs of Rhinoceros Auklets (*Cerorhinca monocerata*) and Cassin's Auklets (*Ptychoramphus aleuticus*), and other available prey items from three regions of Triangle Island. Carbon isotopes can be used to distinguish marine vs. terrestrial diets, whereas nitrogen isotopes serve as useful indicators of trophic position. Mice were segregated into two groups corresponding to areas where only Cassin's Auklets bred or where they bred Rhinoceros Auklets. Isotopic signals from mice eating seabird eggs showed much smaller variances than signals of mice trapped before seabirds began to breed, suggesting that mice diversify their diet in winter.

PATTERNS OF PRIMARY AND SECONDARY MOLT IN LAYSAN AND BLACK-

FOOTED ALBATROSSES: COMPLEX PATTERNS ALLOW FEATHER REPLACEMENT TO MATCH FEATHER WEAR

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Albatrosses are incomplete molters, which means generally they replace only a portion of their flight feathers during a single season. Incomplete molt suggests a trade-off between time available for molting and time available for reproduction. Evidence from annually breeding albatrosses shows that successful breeders molt fewer feathers between two consecutive breeding seasons compared to unsuccessful breeders that abandon the colony early. Successful breeders of biennially breeding albatrosses skip a year of breeding and can undergo a complete molt, whereas unsuccessful breeders which leave the colony early molt fewer feathers and attempt to breed the following year. We examined 104 actively molting, non-juvenile Laysan and Black-footed Albatrosses caught in driftnets in the North Pacific during the non-breeding season in 1990-91 to look at the rules of feather replacement. Both Laysan and Black-footed Albatrosses divide the primary and secondary molt into a total of four series. Each series shows variable feather replacement. There is a hierarchy of replacement between series that depends on a) the average amount of wear received by a series, b) the average age of feathers in a series, and c) the total number of feathers to be replaced in the wing. Multiple molt series and variation in the frequency of replacing feathers within each series allow the pattern of feather replacement to more accurately match the pattern of feather wear, thereby minimizing the cost of maintaining quality feathers.

TRACING AND DEMOGRAPHIC MODELING OF BYCATCH BIRDS: THE CONTRIBUTION OF GENETICS

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Assessing the geographic sources and demographic consequences of bycatch are two important goals in the conservation of the world's seabirds. Large-scale banding operations and satellite tracking offer two potential methods for tracing the origins of bycatch birds, but even the largest sample sizes used in these methods can yield imprecise estimates of the source populations of bycatch birds and the metapopulation context in which bycatch takes place. Molecular genetic markers offer a complementary and non-destructive method for variety of goals toward understanding the biology of bycatch birds. Genetic markers currently available for such studies include mitochondrial DNA sequences, simple-sequence repeats and intron sequences from the nuclear genome. Genetic markers provide powerful clues to the ancestry and geographic origins of bycatch birds and are essential for estimating rates of immigration into fishing grounds and between breeding colonies. Multi-colony genetic surveys of procellariiform and alcid species routinely challenge the traditional view from banding that seabirds are extremely philopatric. Estimates of gene flow from such studies are critical for informed demographic modeling of bycatch species. Genetic markers frequently yield data addressing long-term, evolutionary times scales but can also be analyzed to delimit short-term management units for conservation. Applications of genetics in bycatch biology, illustrated with examples from albatrosses and

alcids, are still in their infancy and the extensive population genetic literature on marine turtles provides useful models.

IMMUNE FUNCTION AS A BIOMARKER FOR CONTAMINANT EXPOSURE IN SEABIRDS: DEVELOPMENT OF SAMPLE STORAGE AND ANALYSIS METHODS

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There is need to develop more sensitive and useful biological markers of contaminant-induced effects on seabirds. The immune system may be useful in this regard since its complexity renders it sensitive to chronic sub-lethal contaminant exposure. The few studies evaluating contaminant effects on immune function in wildlife show strong evidence for contaminant-induced immunosuppression. Here we evaluate methods for isolation of white blood cells (WBC), cryo-preservation, and assessing function of peripheral WBCs collected from a variety of seabirds. We found double density gradient centrifugation recovered both monocytes and lymphocytes from whole blood collected from Common Murres (*Uria aalge*), Magellanic Penguins (*Spheniscus magellanicus*), Greater Scaup (*Aythya marila*), and Double-crested Cormorants (*Phalacrocorax auritus*). We were successful (>80% viability) with cryo-preservation of WBC from Magellanic Penguins, Greater Scaup and Double-crested Cormorants. In addition, a lymphocyte proliferation assay was evaluated with both fresh and cryo-preserved Greater Scaup and Double-crested Cormorant WBCs. Results to date suggest that this assay will be a sensitive and useful tool for evaluating immune function in seabirds. These newly developed methods will be used in a larger field study of contaminant-induced immunosuppression in wild populations of Double-crested Cormorants. Ultimately, the results of this research may provide a field method that utilizes immune function as a biomarker for secondary effects from sub-lethal chronic contaminant exposure.

CAN BURROW-NESTING SEABIRDS BE IDENTIFIED FROM THEIR BURROW DIMENSIONS?

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To reduce disturbance and increase efficiency, the Alaska Maritime National Wildlife Refuge calculates densities of burrow-nesting seabirds indirectly by counting numbers of small-, medium-, and large-width burrows, with the assumption that birds occupy burrows equivalent to their body size. Burrow width criteria that differentiate species, however, are based on data collected in British Columbia and may not be appropriate for other sites. The objectives of this study were to evaluate and improve this method at Buldir Island, Alaska. During the summers of 1995 and 1996, we measured width and height of 391 burrows, and subsequently verified the species occupying each burrow. We found the current model incorrectly predicted the species in 38% of the burrows. To improve the accuracy of the method, we revised the burrow size criteria based on both mean burrow width and height for each species. The revised size classes were

significantly correlated with the expected species and predicted the correct species in 80% of the burrows. We then used the revised size criteria to design a measuring device to distinguish between species at the burrow entrance. The improvement in species prediction from revised size criteria suggests that the measuring device can be used to monitor densities of burrow-nesting seabirds accurately, quickly, and with negligible disturbance at Buldir Island, Alaska.

SET GILLNET EFFORT AND SEABIRD BYCATCH IN THE MONTEREY BAY REGION, CALIFORNIA, 1990-97

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During the 1980's, extensive bycatch of seabirds and marine mammals in central California's set gillnet fisheries prompted a series of area closures and restrictions in shallow waters, which ultimately appeared successful at reducing mortality of the species of primary concern, Common Murre (*Uria aalge*), sea otter (*Enhydra lutris*) and harbor porpoise (*Phocoena phocoena*). The effects of the restrictions, however, were confounded with changes in the distribution of sets and a decrease in total fishing effort in the early 1990's. Since 1994 (after a monitoring program ended), gillnet effort in the Monterey Bay region has again increased dramatically and shifted back into the southern bay, where effort and bycatch previously were high. In this study, updated estimates of seabird mortality are presented for 1990-97 based on 1987-94 fishery observer data. The most commonly entangled seabird was the Common Murre, with mortality estimates ranging from 300 in 1993 to 4,000 in 1997 (1990-97 mean = 1,988). Cormorants, grebes, and loons were less frequently observed entangled. The recent increase in gillnet effort in southern Monterey Bay appears to be reflected in higher beach deposition rates for Common Murre in 1997-98 compared to 1992-93. These changes in fishing effort and distribution underscore the importance of considering variability in both fishing practices and seabird distribution when evaluating longterm fishery impacts on seabird populations.

MORTALITY OF MIGRATORY WATERBIRDS IN MID-ATLANTIC COASTAL ANCHORED GILLNETS DURING MARCH AND APRIL, 1998

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The U.S. Fish and Wildlife Service recently completed the first year of a study to assess bird mortality in anchored gillnets in the nearshore ocean of New Jersey, Delaware, Maryland, and Virginia. Twenty five dead birds were observed being removed during 161 net retrievals. This equates to a minimum mortality of 0.16 birds per 300 foot net per set. Based on approximately 14,900 net sets, we estimate 2,387 diving birds were killed, mostly red-throated and common loons. Beached bird surveys were conducted from 3 to 19 times at 20 locations along the 565 kilometer shore. Two hundred and ten (210) dead diving birds were found on 1,732 kilometers of surveyed beach or 0.12 birds/kilometer. Approximately ten times more dead birds/kilometer were found on beaches within 2 kilometers of at least one gillnet than on beaches without nets. Two methods of estimating mortality based on the beached bird surveys estimated 1,265 and 3,390 diving birds killed per season. Live birds were counted to 400 m offshore on 590

kilometers of shore with nets deployed within 1 kilometer, and on 953 kilometers of shore with no nets deployed within 1 kilometer. For all diving birds, 10.3 birds/kilometer were counted in nearshore waters without nets and 4.6 birds/kilometer were counted in areas with nets. A vulnerability index was developed based on foraging behavior, distance from shore, and time in the study area during migration.

PARENTAL EFFORT AND PREY SELECTION BY MALE AND FEMALE CRESTED AUKLETS ON BULDIR ISLAND, ALASKA

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For three breeding seasons we investigated whether male and female Crested Auklets adopt similar roles in parental care. We found intersexual differences in feeding and brooding rates between males and females, particularly during the first two weeks of chick rearing. Females fed their chick at significantly higher rates than males, whereas males guarded their chick more. We hypothesized that males brood more because they are more aggressive in agonistic interactions and are therefore better at protecting their chick from aggression by prospecting birds. To explore how vulnerable unattended young chicks were we placed clay model chicks in old crevices during three different time periods and found high rates of attacks occurred during each trial (71-87%). We also examined prey selection during the chick rearing period by males and females and found that males selected more euphausiids and fewer copepods than did females. Crested Auklets have developed well defined sexual roles in parental care, especially early in the chick rearing season. Consequences of this division of labor may be sexual differences in mortality; females may be more vulnerable to predators with increased frequency of movement to and from the colony. Also, inter-sexual variation in prey selection may be related to the dimorphism of bill shape; males have a much larger bill that may be suited for larger prey items such as euphausiids.

MOLECULAR EVIDENCE FOR HYBRIDIZATION BETWEEN COMMON AND THICK-BILLED MURRES IN THE NORTH PACIFIC

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The extent of hybridization between common murres (*Uria aalge*) and thick-billed murres (*U. lomvia*) has been the subject of debate. For example, Cairns and De Young's (1981) morphological description of a probable hybrid at a colony in Newfoundland was questioned by Sluys (1983). Using molecular methods, Friesen et al. (1993) discovered a second generation hybrid at a colony in Norway, but this bird was the only hybrid identified during an extensive survey of genetic variation among common and thick-billed murres breeding in the North Atlantic. In a recent survey of variation in mitochondrial DNA in 120 common murres sampled from the Gulf of Alaska and Aleutian Islands, six (5%) were found to possess DNA sequences characteristic of thick-billed murres. Surveys of variation in nuclear introns and microsatellites revealed that these birds carried various combinations of alleles from common and thick-billed

murres, indicating that they represent a mixture of F1, F2 and back-cross hybrids. No hybrids were found in a sample of murres from the western Aleutians. These results have implications both for understanding the evolutionary history of murres and for the conservation of murres in the North Pacific.

SENSITIVITY OF BREEDING PARAMETERS TO FOOD SUPPLY: A CONTROLLED FEEDING EXPERIMENT IN A KITTIWAKE COLONY

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To determine if food availability is responsible for the chronic breeding failure of Black-Legged Kittiwakes (*Rissa tridactyla*) on Middleton Island, AK, we supplementally fed herring *ad libitum* to non-captive adults and nestlings in 1996 and 1997. Birds nested on an abandoned radar tower that provided uniquely accessible sites for experimentation and manipulation. About 150 nest sites were fitted with feeding tubes and sliding, one-way glass windows that permitted us to monitor closely a number of breeding parameters in fed and unfed pairs. Our results indicate that kittiwake productivity was dramatically increased when birds were fed and that this increase occurred through enhancements of breeding performance at all stages of the breeding season. Six measures of breeding performance were especially sensitive to food supply: laying and hatching dates, volume of the "B" egg, foraging trip lengths, chick growth, adult attendance during chick rearing, and chick survival. We suggest these parameters will be the most useful indices of food availability at kittiwake colonies under natural conditions. Breeding parameters less sensitive to food supply included courtship behavior, chick aggression, age of peak weight and fledging ages.

TIMING OF NESTLING ABANDONMENT BY TUFTED PUFFIN (*FRATERCULA CIRRHATA*) PARENTS ON TRIANGLE ISLAND, BRITISH COLUMBIA: A PROPOSAL

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The Tufted Puffins (*Fratercula cirrhata*) breeding on Triangle Island, British Columbia have experienced total reproductive failure in 4 of 5 years, between 1994 and 1998. Chick growth rates in the 1990's are low and adults consistently abandon the nestling in mid to late July, before the chick is able leave the burrow and feed independently. What influences the adults' decision to abandon is poorly understood. Life history theory predicts a trade-off between current and future reproduction. Adults should abandon the breeding attempt when the costs of provisioning outweigh the benefits in terms of their lifetime reproductive success. The objective of this study is to investigate the factors that determine when a parent abandons its young. I will study the timing of abandonment in relation to nestling age, mass, growth rate and adult provisioning behaviour. I will conduct intensive focal point observations of breeding pairs to determine provisioning rates, bill load size and composition, and the date when adults abandon. Measurements of nestling mass gain and wing growth will also be taken. I predict positive relationships between the size of the bill loads, frequency of feeding, nestling growth rate, and the date of abandonment. To experimentally investigate one part of this prediction, I will compare nestling growth rate and timing of parental abandonment in a group of nestlings supplementary fed with Herring (*Clupea harengus*) with an unmanipulated control group.

ADULT PREY CHOICE AFFECTS CHICK GROWTH AND REPRODUCTIVE SUCCESS OF PIGEON GUILLEMOTS

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Pigeon Guillemots (*Cepphus columba*) forage near shore and feed their chicks both demersal and schooling fishes. Between 1979 and 1997, we studied chick diet, chick growth rate, and reproductive success of Pigeon Guillemots at Naked Island, Prince William Sound, Alaska, to identify factors limiting guillemot breeding populations. We found evidence for prey specialization among individual adult guillemots, but detected no differences in reproductive success between specialists and generalists. We did, however, find significant differences in chick growth and reproductive success between pairs that fed their chicks > 50% high-lipid schooling fishes (predominantly Pacific sand lance *Ammodytes hexapterus* and Pacific herring *Clupea pallasii*) and those that delivered > 50% low-lipid demersal fishes (e.g., sculpins Cottidae spp., blennies Stichaeidae and Pholididae spp.) and gadids (Gadidae spp.). The improved growth of guillemot chicks fed high-lipid fishes may be a function of the higher energy density of these prey, however, pairs delivering high-lipid fishes had higher delivery rates than pairs delivering low-lipid fishes. Chick diet showed high annual variation from 1979-1997, largely because of fluctuations in Pacific sand lance. Regression analyses suggest that at the population level, chick growth is affected by the percent occurrence of high-lipid fishes in the diet. We conclude that guillemot chicks grow fastest, and reproductive success is highest, when high-lipid schooling fishes comprise a major portion of the diet.

SURVIVAL AND BEHAVIOR OF WESTERN GULLS FOLLOWING EXPOSURE TO OIL AND REHABILITATION

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Legislatively mandated rehabilitation of wildlife damaged in coastal oil spills has resulted in professionally supervised rehabilitation in California. We evaluated the survivorship and behavior of western gulls that were rehabilitated following the *Platform Irene* spill in California. Western gulls were selected because an adequate sample was available and controls could be obtained.

Three test groups were established: oiled and rehabilitated (n=7), rehabilitated but not oiled (n=10), and controls (captured and released; n=10). Radio transmitters were attached. Aircraft were used to locate birds twice a week for the first 3.5 months, and once a week thereafter. Flight patterns were extensive once radios began to fail (to ensure that all radios were found) and extended from central Baja California to the Oregon-Washington border. The last two radios in the oiled group expired 235 days following release.

One control bird died 115 days after release. The first radio expirations occurred at 127, 52, and

99 days after release for oiled, rehabilitated only, and control birds, respectively. The rate of disappearance of radios was greatest for the control group and lowest for the oiled group ($p < 0.001$); if disappearing radios represented mortalities, such mortalities were fewest in the oiled group. We also examined free-ranging behavior differences between groups by comparing the sizes of areas used by the gulls (adaptive kernel and minimum convex polygon), and shifts in the centers of activity.

COMMON MURRE (*URIA AALGE*) MORTALITY ALONG WASHINGTON OUTER-COAST BEACHES: PATTERNS AND IMPLICATIONS FOR BREEDING POPULATIONS

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We marked bird carcasses with a unique combination of colored cable ties on the bill, wings and/or legs, or we removed them for necropsy analyses. For all birds, we collected data on species, age class, evidence of breeding, indices of body condition, and carcass mass. In all years, Common Murres (*Uria aalge*) composed the majority of beached birds (79% of 1800 birds in 1997). Deposition rates (murres/mile/week) were highest during the El Niño year of 1997 and lower in both 1996 and 1998, a pattern consistent with a similar study conducted around the 1982-1983 El Niño. Necropsies were performed on murres collected in 1997 and 1998 to verify sex and breeding status. The sex ratio of murres sampled was strongly female-biased for reproductive adults (those with brood patches) but not for non-breeding adults. In mid- to late June, females represented 75-100% of the breeding murres sampled on both the northern and southern Washington coast, decreasing to 35% of those sampled by late July. Evidence suggests that food supply was low around many murre breeding colonies in Oregon in 1997 and 1998 causing a large percentage of adult birds to abandon their colonies. We suggest that the physiological cost of egg production by females is the primary cause for the differential mortality rate between males and females.

NEST SITE SELECTION BY MARBLED MURRELETS ON THE OLYMPIC PENINSULA, WASHINGTON

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We examined habitat selection of the Marbled Murrelet utilizing use versus availability analyses and described the characteristics of Marbled Murrelet nests on the Olympic Peninsula, Washington. Nests were found in 1996 (n=4), 1997 (n=15), and 1998 (n=10). Twenty-nine nests were located using intensive, systematic tree climbing methods in 6 sites of varying age and tree species composition. All 1,545 potential nest trees in sixty random plots (40 meter radius) were climbed. Habitat variables were measured and analyzed at four hierarchical scales at nest and non-nest sites; including stand, plot, tree, and limb/platform levels. Western Hemlock (n=25) and Sitka Spruce (n=2) trees appeared to be selected for nesting, with no nests located in Western Red Cedar or Silver Fir. Three nests were located in Douglas Fir trees at sites on the north side of

the Olympic Peninsula where Douglas Fir is often the sole dominant tree species. The selection of particular tree species for nesting has major implications on how land managers: 1) assess habitat quality; 2) protect nesting habitat; 3) improve habitat quality; 4) develop new habitat and; 5) gauge the contribution of particular forest types to the conservation of the population. We also examined differences in microclimatic conditions (humidity, temperature, solar radiation) between a sample of nest and non-nest plots and analyzed whether edge effects lead to degradation of nesting habitat.

TESTING ASSUMPTIONS OF THE LINE TRANSECT SAMPLING METHOD USED TO ESTIMATE MURRELET DENSITIES AT SEA

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Applying distance sampling techniques to marine surveys for Marbled Murrelets may provide biologists with a powerful yet practical methodology for estimating density of populations and monitoring changes in density over time. Unbiased estimates of density can be obtained using the line transect sampling method only if certain assumptions are met. These assumptions are that birds directly on the line are always detected ($g[0] = 1$) and that birds are detected at their initial location, prior to any movement in response to the vessel. We examined the validity of these two assumptions by placing an independent observer behind the two primary observers positioned on the bow of survey vessels conducting surveys for murrelets and other seabirds in Oregon and Washington. The independent observer, using binoculars, located birds near the transect line an average of 156 m ahead of the survey vessel before movement or avoidance would be expected to occur, and then tracked the bird as the boat passed. Birds observed near the transect line moved an average of 3.3 m away from the line before detection by the standard observers. On average, 9.2 percent of the birds near the transect line were not detected by either primary observer. Using DISTANCE software, we estimated the affect of these errors on density estimates. The implications of murrelet avoidance movement and birds missed near the transect line in obtaining unbiased estimates of density using the line transect method are discussed.

INLAND MARBLED MURRELET SURVEYS IN THE OLYMPIC EXPERIMENTAL STATE FOREST, WASHINGTON, U.S.A.

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The Washington Department of Natural Resources (DNR) is conducting inland surveys for marbled murrelets (*Brachyramphus marmoratus*) to develop an inventory of murrelet use of state forests. Information from these surveys will be used, along with additional knowledge and hypotheses, to develop region-specific, long-term conservation strategies. DNR began extensive surveys in the Olympic Experimental State Forest (OESF) on the western Olympic Peninsula in 1996. Preliminary analyses of data from a separate study of murrelet habitat relationships allowed us to develop an aerial photography-based model of "clearly good potential habitat" that was specific to the OESF. Using this model, we identified 16,800 ha of generally low to mid-

elevation, western hemlock-dominated (*Tsuga heterophylla*) old-growth forest patches variously scattered across the much larger commercial forest landscape. From them, we delineated 427 survey sites (10,983 ha), averaging 26 ha in size, 2-35 km from the ocean. During 1996-98, two-year surveys for occupancy according to the Pacific Seabird Group protocol (1994, 1995) found: 217 occupied (5,911 ha), 182 presence (4,430 ha), and 28 no detection (643 ha) sites. We found occupancy in 92 of 203 (45%) sites near the ocean (2-14 km), compared to 125 of 224 (56%) more distant (14-35 km) sites; and occupancy in 27 of 95 (28%) sites in small habitat patches (<80 ha) compared to 190 of 332 (57%) sites in larger patches. Work is in progress completing surveys in the remaining 5,800 ha of "good habitat".

OSCILLATIONS IN THE NORTH ATLANTIC AND SOUTHERN HEMISPHERE: GULF STREAM LAGS AND PETREL PILE-UPS

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In response to steep pressure gradients across the North Atlantic and Southern Pacific Oceans (high values of the NAO and ENSO indices, respectively), the mean position of the Gulf Stream current shifts northward after a two-year lag. This northward movement of the Gulf Stream displaces storm tracks over the Northwest Atlantic, and broadly influences weather patterns over Western Europe. Although the resulting effects have been hard to detect in local meteorological observations, linkages between the northward movement of the Gulf Stream and the incidence of several biological phenomena (changes in marine zooplankton abundance, vegetation dynamics, etc.) are firmly established. So far, no reports have related extremes in the NAO and ENSO (and the lagging northward movement of the Gulf Stream) to changes in the distribution, abundance, or demography of North Atlantic seabirds. Black-capped Petrels are closely tied to the Gulf Stream; they track its onshore and offshore movements and accumulate along the troughs of meanders. Since the oceanographic bases for these associations are understood, the consequences of northward movement of the Gulf Stream on the distributions of Black-capped Petrels can be predicted and then related to broader-scale forces, the NAO and ENSO. During the course of my pelagic surveys off North Carolina (1992-96), the annual abundance of Black-capped Petrels was markedly elevated in only one year — the only year in which the NAO-lagged index was low (0.0) and conditions favoring upwelling at Cape Hatteras were enhanced.

COASST: DEAD BIRDS, LIVE(LY) FEEDBACK

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COASST, Coastal Observation and Seabird Survey Team, is a volunteer-based beached bird survey program currently under development by the University of Washington and the Olympic Coast National Marine Sanctuary. Drawing from a variety of existing beached bird and other volunteer-based science programs, COASST is designed to track carcass deposition and the factors affecting deposition along the beaches of the outer coast of Washington State. Volunteers are assigned to a knowledge level (1-4), based on the outcome of a post-training field test, where level one is open to everyone and level 4 designates a highly skilled beach-birder. Additional levels (5-6) are reserved for university and museum work. At present COASST is developing along four lines: (1) Creation of a datasheet which combines physical, environmental, and

biological data. All data collection is geared towards operational, rather than judgmental, decisions. (2) Creation of a program protocol which will be used during the volunteer training program and as a volunteer "bible" in the field. (3) Creation of a full-color beached bird field guide designed to show seabirds in death rather than life. (4) An outreach program to create a volunteer base. In this poster, we present our draft data sheet, protocol, and a sample page of the field guide. We welcome your feedback!

ADULT SURVIVAL AND FORAGING PATTERNS OF PIGEON GUILLEMOTS, *CEPPHUS COLUMBA*, ON SOUTHEAST FARALLON ISLAND

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We estimated annual survival rates for individually color-banded pigeon guillemots on Southeast Farallon Island using mark/recapture analyses ($n = 80$). Preliminary results (before correcting for band loss) indicate an annual survival rate of 0.88 (0.02 SE) from 1988 to 1994. No significant variation among sexes or years (including effects of the 1991-92 El-Niño event) was detected, although sample sizes of known-sex birds were small (21 males; 17 females). Given high nest site fidelity and survival of adults, we used a larger sample of sites (~110 sites, including unbanded birds) in which chick diet composition and feeding rates were monitored daily from chick hatching to fledging from 1988 to 1998 (~28,000 observations) to: (1) characterize diet specialization using multivariate clustering techniques; (2) test for effect of diet composition on feeding rate; and (3) test for effects of feeding rate and diet composition on chick growth patterns and fledging success. Lastly, we examined relationships between foraging and reproductive parameters and adult survival using mark/recapture analyses. This study provides insight into mechanisms responsible for correlation between diet composition and fitness components; and the larger repercussions of changes in food web structure to the dynamics of seabird populations in coastal California.

CHANGES IN DIET OF TERNS AND SKIMMERS NESTING AT THE WESTERN SALT WORKS IN SOUTH SAN DIEGO BAY, CALIFORNIA: APPARENT RESPONSES TO CLIMATE CHANGE AND SHIFTS IN PREY POPULATIONS

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The dikes of the Western Salt Works in south San Diego Bay have been nesting sites of terns for several decades and of Black Skimmer for >20 years. Limited data indicate that Northern Anchovy was the main dietary item for Caspian Terns and Elegant Terns 20-30 years ago, with Pacific Sardine unmentioned as prey. Our recent studies, based on fish dropped by the birds at the colonies and fish scales in pellets regurgitated by the birds at the nests, show changes in diets that appear to be related to ocean warming and shifts in prey populations in California. In 1995, based on dropped fish samples, Pacific Sardine was the most common prey of Caspian Tern and tied with Northern Anchovy for the most abundant prey of Black Skimmer, whereas Northern Anchovy remained the top food item for Elegant Tern. In 1997, based on the same kind of data, Northern Anchovy ranked first and Pacific Sardine second in the diet of Caspian Tern, and Pacific Sardine and California Halfbeak were the two main foods of skimmers. Elegant Terns

failed to nest at the site. Pacific Sardine made up nearly 30% of all dropped fish samples and Northern Anchovy only 11%, compared to 10% and 21%, respectively, in 1995. Preliminary analysis of 1998 data indicates a continuing trend of proportionately more warm-water fish species in the birds' diets.

THE EFFECT OF NEST LOCATION ON BREEDING SUCCESS IN MARBLED MURRELETS: ESTIMATED COST OF NESTING FURTHER INLAND

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Radio transmitters were deployed on 24 Marbled Murrelets (*Brachyramphus marmoratus*) to locate nest sites in Desolation Sound, British Columbia, during the 1998 breeding season. Radio-tracking from a helicopter was used to locate nests, and tracking from the air and water was used to determine attendance patterns of birds, as an indication of breeding. Activity patterns confirmed incubation at 16 nests, and at 12, chick rearing. Inspection of some nests at the end of the breeding season indicated a minimum of three chicks fledged. At three other nests the egg was predated and at another, the chick died. The fate of 11 nests was unknown. Mean elevation of nests was 920 ± 392 m, aspect of $162.2 \pm 116.5^\circ$, with all nests within 50 km of presumed foraging areas. Presumed foraging areas were determined by the density of murrelet locations on the water, derived from radio tracking. A logistic regression was performed on the explanatory variables elevation, aspect and distance from presumed foraging areas to determine their relationship with breeding success. The flight speed of murrelets was calculated from radar and these, along with aspect ratios, were used to estimate the energetic cost of nesting varying distances from presumed foraging areas. The results are compared to other alcids.

RESPONSE OF SEABIRD ABUNDANCE TO LONG-TERM CHANGES IN THE CALIFORNIA CURRENT, 1987-98

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Seabird communities off southern California have undergone gradual and persistent changes (Veit et al. 1996) in response to long-term ocean warming and declining zooplankton biomass since the 1950's (Roemmich and McGowan 1995). In a previous study, Veit and coworkers (1996) reported that overall seabird abundance off southern California had decreased by 40% between 1987-1994, mostly due to the 90% decline in the dominant cold-water species, the sooty shearwater (*Puffinus griseus*).

Here, we provide evidence of subsequent changes in seabird abundance off southern California during 1994-98, a period of continued decreases in zooplankton biomass. Since 1994, total seabird abundance and sooty shearwater numbers have remained consistently lower than during 1987-94, suggesting that the long-term decline off Southern California continues.

In addition to long-term (decadal) trends, short-term (interannual) changes in ocean conditions are known to affect seabird distribution and abundance off southern California (Ainley 1976,

Ainley et al. 1995, Veit et al. 1996). Despite evidence of transient changes in seabird abundance related to warming (e.g. 1997-98 El Niño) and cooling (e.g. incoming 1998-99 La Niña) episodes during 1994-98, the available data suggest that the long-term association between seabirds and oceanographic variability overrides the less persistent short-term trends.

SOME CONCEPTUAL IDEAS CONCERNING SEABIRDS AS INDICATORS OF CHANGING MARINE ENVIRONMENTS

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In Cairns' 1987 paper on seabirds as indicators of marine food supplies, he proposed that the shape of the curves depicting relationships between several demographic parameters of seabirds and the abundance of food were nonlinear. Since Cairns proposed these relationships, data from other studies have indicated that he was at least partly correct in that the relationship between breeding success and food supply is sigmoidal and that breeding success is unaffected by changes in food abundance at levels above a threshold. Here I propose parameters that affect the shape and position of the curve relating seabird breeding success to food supply. I make the following assumptions. There is a positive relationship between food supply and size of seabird colonies. When food becomes scarce, adult seabirds allow their chicks to die at the expense of keeping themselves alive. Adults remain at the colony whether or not they have chicks. Based on the energetic needs, I suggest that 1) the size of a colony determines the position of the curve in relation to food supply and, 2) the ratio of energy needs of chicks/energy needs of adults, determines the general slope of the curve and thereby varies among species. For example, everything else being equal, the position of the curve for a large colony will be to the right (higher food abundance) of a curve for small colonies (lower food abundance), and murrelets (small ratio) will have a greater slope than kittiwakes (large ratio). These predictions are testable and may help us to understand more about how seabirds indicate changes in the marine environment.

PENGUINS LIMIT FORAGING WHEN FORAGE IS LIMITING: NEW PERSPECTIVES ON STRATEGIES OF LONG-LIVED SEABIRDS

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A central hypothesis of seabird ecology predicts that parents will increase foraging effort to compensate for reductions in food supply, thus sustaining a constant level of provisioning for offspring. Studies apparently supporting this prediction have often used a species' reproductive performance to infer prey status, or have used prey data that are limited in spatio-temporal coverage and/or overlap with foragers. In contrast, theoretical considerations suggest that — under many ecologically realistic circumstances — parents of long-lived organisms should be expected to *decrease* parental effort in response to reduced prey. We related spatially and temporally relevant measures of prey density with at-sea behavioral data from chinstrap penguins collected over 8 years at Seal Island, Antarctica. Our findings were inconsistent with the

hypothesis that parent birds increase foraging effort with declining resources; instead, penguins exhibited shorter diurnal foraging trips when conditions were less favorable. Overnight trips showed no patterns in relation to prey density, but trips spanning a day and night showed signs of a reversed pattern, i.e. trip duration decreased in good years. These trends more closely reflected adjustments in time spent actively foraging than changes in time spent traveling to or from foraging grounds. The close proximity of Seal Island to a relatively productive marine environment may afford penguins that nest there greater flexibility in foraging tactics relative to penguins that breed at less favorable sites.

SEABIRDS AT CASTLE ROCK NATIONAL WILDLIFE REFUGE, CALIFORNIA: POPULATION STATUS, LONG-TERM TRENDS, AND EFFECTS OF THE 1997-98 ENSO EVENT

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Population size of three alcid and three cormorant species breeding at Castle Rock NWR were estimated in 1997 and 1998 as part of a new annual seabird monitoring program. These data were compared with estimates collected at approximately decadal intervals since 1970. The more pelagic foraging species (Common Murre, Tufted Puffin, and Brandt's Cormorant) showed evidence of recent decline, whereas the nearshore foraging species (Pigeon Guillemot, Pelagic and Double-crested Cormorant) did not. Numbers and productivity of all species except the Double-crested Cormorant were depressed in 1998. Common Murres attended the colony throughout the 1998 breeding season, but experienced nearly complete reproductive failure. Tufted Puffin numbers were the lowest on record. The impacts of oceanographic conditions, historic human activities, and ecological changes on the island including intensive use of the refuge by a soaring population of Aleutian Canada Geese, are discussed in relation to long-term seabird population trends.

EFFECTS OF SUPPLEMENTAL FEEDING LATE IN THE CHICK-REARING PERIOD ON PREFLEDGING MASS RECESSION

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Prefledging mass recession is exhibited by nestlings in many alcid species and there are several competing hypotheses regarding the reason for this phenomenon. I conducted a supplemental feeding experiment to explicitly test whether prefledging mass recession reflects a reduction or cessation of parental provisioning. All chicks were weighed daily from 30 days of age until fledging to examine growth patterns as the chicks approach fledging. Chicks in the experimental group were supplementally fed (50g herring) each morning from 40 days of age until fledging. If pre-fledging mass recession is caused by parental abandonment, chicks provisioned supplementally should show no prefledging mass recession. Additionally, if the nestling departure decision involves anticipated future provisioning, supplemented chicks would be expected to fledge older than control chicks. However, if chicks are chronically overprovisioned and lose mass to optimize fledging mass or wingloading, supplemented chicks should exhibit the characteristic prefledging mass recession accompanied by rejection of supplemented food. The

data demonstrate that pre fledging mass recession is a consequence of reduced parental provisioning and that chicks decide when to leave the burrow based, in part, on their preceding growth rate.

A VIEW FROM THE BURROW: BREEDING BIOLOGY OF RHINOCEROS AUKLETS ON TRIANGLE ISLAND

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Nest attendance, incubation behavior, egg depredation, and parent-offspring provisioning interactions are frequently assessed with observational data. However, these aspects of the breeding biology of burrow-nesting seabirds can be problematic to examine because nest chambers are normally concealed from view. We will demonstrate the usefulness of one approach to this problem: the use of an infra-red burrow probe which allows direct observation and video footage to be obtained in real time. We will present videotaped footage obtained from burrows on Triangle Island, British Columbia, using this technique, that has significantly contributed to our knowledge of rhinoceros auklet breeding biology.

MARBLED MURRELET DAYTIME CHICK FEEDING BEHAVIOURS SUGGEST REVISITING PROTOCOLS

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The Caren Range on British Columbia's Sunshine Coast yielded Canada's first active Marbled Murrelet nest in 1993. Out of 101 chick feedings of this species monitored by the author and a small group of researchers representing Friends of Caren at two separate nest sites and three nestings during 1993, 1994 and 1997, 65 feedings took place after sunrise, one as late as 12:07 hrs. (Pacific Daylight Time). Of those observed after sunrise, 21 feedings took place before 7am, 24 between 7am and 9am, and 20 between 9am and 12:30pm (PDT). These findings suggest that Marbled Murrelets spend much of their time during the breeding season flying to and from the forests where they breed in broad daylight, contrary to the popular belief about the crepuscular nature of this species. Most of the flights to and from nests were direct, with no circling flights observed within 500 metres of the nests. These findings suggest that PSG protocols pertaining to inland behaviours should be revisited and revised, at least for Canada, and possibly for the entire range of this species.

DETECTING INTRA- AND INTER-ANNUAL VARIATION IN PREY AVAILABILITY USING DAILY FORAGING TRIP DURATIONS

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The daily energy expenditure (kj/day) of Black-legged Kittiwake nestlings steadily increases until 23 days of age (Gabrielsen et al. 1992). Response in foraging activities of adult kittiwakes to increasing energetic requirements of their nestlings should differ in three predictable ways depending on prey availability. 1) If prey are easily obtained and the distribution is unchanged

throughout nestling development, then negligible effort is required to obtain additional prey and foraging trip duration should remain relatively constant throughout the chick rearing period. 2) If prey are difficult to obtain and availability does not change, then we would predict a steady increase in foraging trip duration and an asymptote when nestlings reach 23 days old. The slope of the curve should reflect the relative difficulty of obtaining prey. 3) If there is within season variation in prey availability, then we should observe an unexpected change in foraging trip duration that is inconsistent with response #1 or #2.

We used data collection computers to monitor daily colony attendance of radio-tagged, adult Black-legged Kittiwakes during three years (1995-97) at three colonies in Prince William Sound, Alaska. Analysis of mean daily trip durations provided examples of the three responses described above. Abrupt or otherwise unexpected changes in trip duration (response #3) typically corresponded with changes in species and/or quantities of prey consumed. Preliminary results indicated that comparing daily foraging trip durations to our three hypothetical responses may provide valuable information about intra- and inter-annual variation in prey availability.

BARREN ISLANDS SEABIRD STUDIES

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To study the response of seabirds to changes in food availability and quality during the breeding season, since 1995 we annually collected data on several breeding and foraging parameters of surface-feeding and diving seabirds (Common Murre, Black-legged Kittiwake, and Tufted Puffin) at the Barren Islands, Alaska. Breeding parameters included nesting chronology, productivity, and chick growth rate; foraging parameters were adult nest attendance and foraging trip duration, and chick feeding frequency and meal size. We monitored the prey base by examining chick and adult diets and by beach seining. A related study conducted hydroacoustic and trawl surveys to obtain additional information on the food web. During the summer of 1998 nesting was late and productivity declined for all three species. Measurements of other parameters varied among species. While sea surface temperature near the breeding colony was not unusually high during the summer, warm water from the 1997 ENSO did flow into this area during the previous winter. This event may have made forage fish less available to seabirds during the pre-breeding season and caused late nesting and reduced breeding success. This poster compares 1995-1998 results from this five-year study.

EFFECTS OF WIND ON THE GROWTH RATE OF KITTIWAKE CHICKS

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Potential effects of wet, windy conditions on breeding seabirds are particularly severe for cliff-nesting, surfacing-feeding species such as Kittiwakes. I studied the effects of wind on growth rates of Red-legged (*Rissa brevirostris*) and Black-legged (*R. tridactyla*) kittiwake chicks at St. George Island (southeastern Bering Sea) in 1993 and 1994. I weighed chicks every 3 - 5 days and compared mass increments (g/day) of each chick between time intervals with "windy" (wind > 25 km/h was sustained for more than 25% of interval) vs. "calm" conditions in paired-sample analyses. I used a two factor ANOVA to evaluate effects of nest exposure and species on the

response of chick growth to wind, and found significant effects of both factors in both years. Strong winds suppressed growth rates of chicks exposed to severe updraft conditions at high-elevation sites relative to those of chicks located in less-exposed nests at lower elevations, an effect that was likely due to greater energetic demands of thermoregulation for chicks in exposed nests. In addition, windy weather also suppressed growth rates of Black-legged vs. Red-legged kittiwake chicks: the growth rate of Red-legged kittiwake chicks in sheltered nest sites was enhanced during windy weather while that of Black-legged kittiwakes was somewhat diminished. I speculate that the differing response of the two species is a consequence of differing effects of wind on flight energetics or foraging efficiency of adults which ultimately affect chick provisioning and growth rate.

MOVEMENTS OF AMERICAN WHITE PELICANS BANDED AT MARSH LAKE, MN

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We analyzed 625 recovery records for American White Pelicans (*Pelecanus erythrorhynchos*) banded at Marsh Lake, MN between 1972 and 1996 to determine migration and dispersal patterns. Recoveries included 542 dead birds, 39 birds that were subsequently released, and 44 birds of unknown fate. Median age at recovery was 1.0 year. The longest distance between banding and recovery was approximately 3200 km. Pelicans from Marsh Lake migrated through the Great Plains and along the Mississippi River. Most birds spent the winter south of latitude 35° N in the lower Mississippi River Valley and the states and countries bordering the Gulf of Mexico. Between November and March, only 53 (9%) of 567 recoveries with accurate dates were retrieved above this latitude. Two-hundred and ten bands (34% of the total) were recovered south of latitude 35° N: 127 (60.5%) in the United States, 74 (35.2%) in Mexico, 6 (2.9%) in Guatemala, 1 (0.5%) in Honduras, 1 (0.5%) in Nicaragua, and 1 (0.5%) in Cuba. The effect of southeastern aquaculture on the winter distribution of pelicans will be discussed.

CONSEQUENCES OF VARIABILITY IN PREY ABUNDANCE AND PREY ENERGY CONTENT FOR BREEDING PIGEON GUILLEMOTS

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During 1995-1998 we measured forage fish abundance and Pigeon Guillemot (*Cephus columba*) chick diet composition, provisioning rates, and chick growth rates in Kachemak Bay, Alaska. Pacific sand lance (*Ammodytes hexapterus*) comprised the majority of diets at some guillemot colonies, and we used our data to examine the possible advantages and disadvantages that a diet rich in sand lance would convey to breeding guillemots. We hypothesized (1) that the high caloric value of sand lance would translate to higher growth rates and/or reduced parental effort during provisioning; and (2) that temporal fluctuations in sand lance abundance would far exceed those of benthic fish, yielding greater variability in chick growth rates. Our data

supported the first hypothesis; growth rates were positively correlated with the proportion of sand lance in the diet, and a diet rich in sand lance allowed parents to increase provisioning rates (kJ / h) without increasing delivery rates (meals / h). The second hypothesis was not supported. Although sand lance abundance varied about 40-fold among years, and benthic fish abundance varied about 4-fold, we found no significant inter-annual differences in growth rates. Guillemots feeding on sand lance were able to buffer against low sand lance abundance by switching to benthic fish.

BIRD-SCARING LINE AND UNDERWATER SETTING REDUCE SEABIRD BYCATCHES IN LONGLINING

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Seabird bycatches in longline fisheries may cause seabird populations to decline and reduce gear efficiency. Different types of mitigation measures capable of reducing the likelihood of seabird incidental catches have been described, but only a few studies to quantify their effectiveness have been carried out. Two fishing experiments in commercial longlining were performed and two different methods of preventing seabirds from taking baits during longline setting were tested: a bird-scaring line towed behind the vessel and an underwater setting funnel. Bycatch of seabirds, bait losses and catch rates of target species were quantified for longlines set using these mitigation measures and compared with those of longlines set without such measures. During 12 settings in the first experiment, two seabirds were caught when the bird-scaring line was used, 28 when lines were set through the setting funnel and 99 when no device was used. In the second experiment, 11 settings were made for each method, and zero, six and 74 seabirds respectively were caught. The great majority (>95%) of the birds caught were northern fulmar (*Fulmarus glacialis*). The relatively high number of seabirds caught in the first experiment by lines set through the underwater setting funnel was explained by the unfavourable pitch angle of the vessel. The results of both experiments showed that bait loss was lowered using the bird-scaring line, and the second experiment indicated smaller catches of target species by lines set without the use of a mitigation measure.

USING MULTIPLE METHODOLOGIES TO DERIVE THE BREEDING PHENOLOGY OF THE MARBLED MURRELET

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We used a multiple methodology approach to derive the breeding phenology of the Marbled Murrelet (*Brachyramphus marmoratus*) at Desolation Sound, British Columbia, and assessed the potential biases of the different methodologies currently used. Marbled Murrelets are unique among alcids in their solitary and elusive breeding habits. This has limited the type and amount of information that can be gathered for this species, resulting in the use of a variety of methodologies to determine phenology. Each methodology is subject to potential biases and therefore, it is important to assess the biases of each of them for an adequate interpretation of the results if we wish to learn more about the life history traits of this species. Parameters used to derive the breeding phenology of Marbled Murrelets have included known egg hatching dates,

observations of young at on nest, grounded chicks or grounded fledglings, juveniles observed to fledge, adults holding fish at sea and presence of a postovulatory follicle or unshelled egg in the oviduct of collected females. We also introduce a new methodology of assessing reproductive status of captured individuals by measuring physiological parameters.

THE CHARACTERISTICS OF 23 MARBLED MURRELET NESTS IN BC LOCATED BY RADIO TELEMETRY

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During early May, 1998, 40 adult Marbled Murrelets (*Brachyramphus marmoratus*) were captured by dip netting in Desolation Sound, British Columbia, and individually fitted with 1.7g radio transmitters. Of these 40 birds, 24 were tracked by helicopter to 23 inland nesting locations (both adults had radios at one nest). The nests were found 1.5 to 35 km from the ocean, and were located in the Powell-Daniels drainage, the Bunster Range, E. Redonda Island, and Toba Inlet. One radio was tracked to the nest of a Bald Eagle (*Haliaeetus leucocephalus*). There were 15 birds with radios that were not linked to nest sites. Those birds were either consistently on the water, and breeding, or had an unknown status. The nests were all located within old growth stands, but the stands were highly variable in tree species composition and topography. I examine the characteristics of these stands in relation to nest success.

STAND AND LANDSCAPE FACTORS AFFECTING EDGE RELATED PREDATION ON MARBLED MURRELET NESTS

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We conducted artificial nest studies on the Olympic Peninsula of Washington (1995 to 1998) and in the Coast Range of Oregon (1997 and 1998) to assess the influences of stand and landscape level variables on edge related nest predation on Marbled Murrelets. We measured nest predation rates up to 300 meters from edge in stands of varying structure, adjacent matrix composition and levels of fragmentation at both the stand and landscape scales. Our results indicate that edge related predation effects in western forests are highly dependent on the surrounding matrix and diversity of the predator community. Edge effects are most likely to occur when the matrix contains habitat and foods used by predators. In our study area these conditions are met when mature forest fragments abut (1) clearcuts with berry crops and (2) human use areas (small towns and campgrounds).

HOW THE F/V MASONIC REACHED ZERO SEABIRD BYCATCH IN 1998 IN ALASKA

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In response to growing international pressure and threats to the short-tailed albatross

(*Phoebastria albatrus*), seabird by-catch regulations were adopted that require fishers to deploy seabird deterrent devices in the Gulf of Alaska and the Bering Sea demersal longline fisheries in 1997. These regulations, which allow a range of alternative strategies, were proposed by industry and were patterned on those developed in the southern oceans and our own history of trying to keep seabirds away from our baited hooks. Alaska fisheries. In order to find the best by-catch reduction strategy for my vessel, I compared several bird bycatch reduction devices and combinations of devices in the Gulf of Alaska during the 1997 and 1998 fisheries for Pacific halibut (*Hippoglossus stenolepis*) and sablefish (*Anoplopoma fimbria*). Devices included towing buoy bags, streamer lines, and boards and increasing the weight of the fishing gear. As a result of my tests, I achieved zero take of seabirds on my vessel in 1998 by increasing the weight of the fishing gear in combination with deploying a streamer line with the fishing gear. Based on my results and that of fellow fishers, the industry is working with resource managers to develop new, more specific seabird by-catch regulations for the 1999 fishing season.

RE-USE OF NEST TREES BY MARBLED MURRELETS

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Re-use of nest trees has important implications for our understanding of the demography and habitat use of Marbled Murrelets. Relatively little is known about the frequency of nest re-use by murrelets either within, between or over multiple years. I determined re-use of nest trees by Marbled Murrelets in the Bunster Range, located in south-western B.C. Re-use was determined using dawn surveys followed by tree climbing for 52 nest trees from 1996-1998. On average 12% of nest trees were re-used during the study. Nest trees were re-used within a breeding season (n=2) and between years (n=8). Re-use of the same nest site, and of different nest sites within a tree were observed. Most re-use occurred at failed nests. Murrelets attended nest trees prior to re-use both within a year and between years. The presence of multiple nest sites within a tree is additional evidence that a tree has been re-used. Twenty percent of the nest trees in this study had 2 to 3 nest sites. Individual birds were not identified during the study. Therefore, re-use of trees may represent breeding site fidelity by the same individuals or use of the same tree by different birds. I discuss the implications of re-use for the conservation and habitat management of Marbled Murrelets.

HABITAT CHARACTERISTICS ASSOCIATED WITH NEST SUCCESS AND PREDATION AT MARBLED MURRELET TREE NESTS

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Marbled Murrelets (*Brachyramphus marmoratus*) are unique among alcids in North America in their use of coastal older-aged coniferous forests for nesting. Despite being cryptic, secretive and primarily crepuscular at nests, they are vulnerable to high predation rates at their tree nests. Most active nests have failed (>65%) and the majority of these were unsuccessful because of predation (>60%). To determine if habitat characteristics influence nesting success, we compared nest site,

nest tree and within-stand characteristics of successful and unsuccessful nests. A sample of nests with known outcomes (successful, failed) from Alaska (n=9), British Columbia (n=34), Washington (n=4), Oregon (n=20) and California (n=10) were used in the analysis. We found that successful nests were further from the stand edge and were closer to the trunk than unsuccessful nests. Survival rates within 50 m of an edge were only 38%, whereas nests >50 m from the edge had a 62% survival rate. Nests located within 0.5 m of the tree trunk were more successful (71%). In addition to nest characteristics and known predators of chicks, eggs and adults at nests, we discuss the implications of nest success to the population status and habitat management of Marbled Murrelets.

TREADING LIGHTLY IN CHANNEL ISLANDS NATIONAL PARK

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Channel Islands National Park and National Marine Sanctuary hosts a unique and diverse spectacle of wildlife. Thousands of breeding seabirds and pinnipeds depend on these isolated islands off the southern California coast. As the population of southern California grows and access to the islands becomes easier, it is vital that we understand how to "tread lightly" on the land and sea. In this video produced by Channel Islands National Park and Spaceport Systems International, we illustrate the beautiful resources of the Channel Islands and techniques you can use to minimize your impact on the wildlife that lives there. Visual images introduce guidelines such as

- pack it in — pack it out
- stay on established trails, and
- maintain a respectful distance from seabirds and pinnipeds both in rookeries and haul outs

to numerous visitors traveling to CINP and CNMS every year to experience hiking, kayaking, and diving. The video project provides a tool to educate the public on the susceptibility of seabirds and pinnipeds to human disturbances including presence and pollution.

DIVERSE COMMUNITIES OF NEST PREDATORS: IMPLICATIONS FOR MURRELET BREEDING SUCCESS

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Our studies (1995-1998) at simulated Marbled Murrelet nests in Washington and Oregon have identified a diverse array of potential nest predators. Predators differ in being (1) nocturnal or diurnal, (2) avian or mammalian, and (3) most common in murrelet nesting habitat or the surrounding matrix. The implications of a diverse predator community include (1) high overall rate of predation (eggs and chicks are vulnerable during day and night), (2) selection for nest/chick concealment and chick/adult defensive ability, (3) complex association between nest

vulnerability and characteristics of the nest stand and surrounding landscape, and (4) complex relationships between the rate of predation and distance of the nest from the forest edge. We discuss how understanding these complexities can affect our management of murrelet nesting habitat. Our results and a review of the nest predation literature suggest that thorough understanding of the nest predators is rare and this reduces our ability to accurately manage nesting habitat.

STELLER'S JAY ECOLOGY IN FRAGMENTED FORESTS OF COASTAL BC, WITH IMPLICATIONS FOR MARBLED MURRELETS

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Steller's Jays (*Cyanocitta stelleri*) eat eggs and chicks of the threatened tree-nesting Marbled Murrelet (*Brachyramphus marmoratus*). Timber harvesting negatively impacts murrelet numbers through forest fragmentation and reduction of old-growth nesting habitat, but may benefit jay populations due to an increase in edge habitat. Information on Steller's Jay ecology is limited therefore I implemented a two-year study (summers 1996-97) to investigate the abundance, distribution, and habitat use of Steller's Jays in fragmented landscapes. The study, located on the southwest coast of Vancouver Island, consisted of three widely separated study sites. At each site, paired 1 km transects (4-5 point count stations per transect), were used to census the relative abundance of jays in two habitat types (forest and edge) and in three location types (road, clear-cut and river). An analysis of variance was performed to test for variation in jay abundance among habitats, locations and sites. Point counts indicate that jay abundance was greatest along clear-cut edges and was significantly higher at edges than interior forest habitat for all location types. Telemetry and focal point observations were used to compare home-range size and fine scale habitat use of two jay groups; those that used clear-cuts (n=6) and those that did not (n=5). Home-range estimates were variable (95% minimum convex polygon, 3.70-50.01 ha.). There was no difference in home-range size or patterns of habitat use between the two jay groups. My data show that murrelet nests located near roads and clear-cuts, are at greater risk to predation by jays.

STATUS AND DISTRIBUTION OF THE ASHY STORM-PETREL ON THE CALIFORNIA CHANNEL ISLANDS, 1991-1997

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We conducted surveys of Ashy Storm-Petrel (*Oceanodroma homochroa*) colonies on the California Channel Islands in 1991-1997. Among the rarest North Pacific seabirds, this secretive species nests primarily in rock crevices in small to medium-sized colonies off the coasts of central and southern California. In 1975-1977, about 600 pairs, or 23% of the known world population, were estimated breeding at eight Channel Islands' colonies. In this study, we

resurveyed known and searched for new colonies using nest searches and mist-netting to provide updated information. We confirmed breeding at 16 colonies, including nine newly-discovered colonies, and suspected breeding at eight others. The largest colonies occurred off San Miguel Island (at Prince Island and Castle Rock) and at Santa Barbara Island. Several new colonies at Santa Cruz Island were in previously unexamined habitats within sea caves. Nesting was confirmed for the first time at San Clemente Island. At Santa Catalina Island, nesting was suspected where breeding has not been documented since 1937. Small numbers of mist-netted birds at Anacapa Island indicated probable breeding but introduced rats may limit population size. We estimate the Channel Islands' population comprises 50-65% of the known world population. However, higher recent estimates are largely due to methodological differences and increased survey effort.

SOLUTIONS AND ROADBLOCKS TO SEABIRD BY-CATCH IN SALMON DRIFT GILLNET FISHERIES IN THE PACIFIC NORTHWEST

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Data from fishery observer programs in the 1993 and 1994 salmon fisheries demonstrated that the Puget Sound gillnet fishery for Fraser River sockeye salmon killed significant numbers of common murres and rhinoceros auklets. The fishery rarely killed marbled murrelets. A multi-year, Washington Sea Grant-industry research program developed and tested gear and methods to reduce seabird bycatch from 1994 to 1996, and generated specific recommendations for regulatory action. In May of 1997, the Washington Department of Fish and Wildlife adopted regulations to reduce seabird bycatch in the non-treaty fishery. These required: 1) the use of gillnets modified to include a visual barrier of heavy white twine in the upper net, 2) prohibition of night and sunrise fishing, and 3) scheduling fishery openings that optimize fishing efficiency and avoid periods of high bird abundance. Neither the Washington tribes nor the British Columbia salmon fishery managers adopted these regulations, leaving approximately 90% to 99% of the salmon fishing effort by gillnets in the Puget Sound-Queen Charlotte Straits Ecoregion unregulated. Intervention by the Pacific Seabird Group and recent FAO action helped catalyze increased attention to gillnet bycatch in Canada and the Washington tribes. The Puget Sound experience illustrates that solutions to seabird bycatch, once found, are not sufficient to affect changes in fisheries management or seabird conservation.

MARBLED MURRELET USE OF LANDSCAPES FOR NESTING IN CALIFORNIA AND SOUTHERN OREGON

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We evaluated marbled murrelet (*Brachyramphus marmoratus*) use of landscapes and the juxtaposition of forest nesting habitat to marine habitat in a study area that extended from Coos Bay, Oregon to Monterey Bay, California. Using GIS and Landsat-derived coverages, fragmentation indices of patches of vegetation classified by seral stage were calculated within

circular plots of 400-m, 800-m, 1600-m, and 3200-m radius. Plots were centered on occupied and unoccupied sites within surveyed stands. We measured distance to nearest marine features, roads, and streams, and recorded topographic and climatic variables from plot centers. Using logistic regression, we found sites occupied by nesting murrelets were closer to major bays and marine areas with high summer primary productivity and were at lower elevations. These sites were in patches having at least 10% of trees in old-growth forest, where the patches were mostly restricted to the redwood vegetation zone in California and the moist coastal Douglas-fir-dominated zone in Oregon. Occupied plots contained more old-growth forest that had complex edge, interior habitat, and nearby mature second-growth forest. They contained fewer patches of young hardwoods and had less complex edge across the landscape. Probability of occupancy increased if a plot was within 5 km of another plot where murrelets were detected.

RECENT DISTRIBUTIONAL RECORDS OF SHORT-TAILED ALBATROSS AS A TOOL FOR LONG-LINE FISHERIES MANAGEMENT

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The Short-tailed Albatross (*Diomedea albatrus*) is vulnerable to accidental catch in Alaska long-line fisheries for species such as Pacific Cod (*Gadus macrocephalus*) and Sablefish (*Anoplopoma fimbria*). Using ArcInfo, we plotted the distribution of this species based on sight records and bycatch. Short-tails occur year-round in Alaskan waters but peak in summer. They are strongly associated with shelf-edges and seamounts in the Gulf of Alaska and along the Aleutian chain and with the edge of the deeper basin of the Bering Sea. Adult and immature distributions do not appear to differ. Short-tails occur in waters less than 50 m depth, but increase in frequency with depth, being commonest at 150 - 200 m depths. This information may help fishermen avoid areas of high concentrations of albatross or take special precautions while setting their long lines in such areas. The distributional maps may be found on the Web at:

http://www.uaa.alaska.edu/enri/aknhp_web/biodiversity/zoological/spp_of_concern/spp_status_reports/albatross/albatros.html

TIME FLIES: BIOPHYSICAL INTERACTIONS INVOLVING SEABIRDS IN THE NW ATLANTIC

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Changes in seabird populations, breeding success and diets are robustly associated with oceanographic changes and perturbations over multiple temporal scales in the NW Atlantic. Growth of the breeding population of gannets is closely associated centennial warming of surface waters and the concurrent movement of warm-water migratory pelagic mackerel and squid into the region. Cold surface water events in the 1990s had profound effects on breeding success of

surface-feeding seabirds but less influence on pursuit-divers. These effects were amplified by the Eastern Canadian Ground Fish Moratorium which eliminated massive tonnages of fishery discards and offal from the NW Atlantic and had profound consequences for scavenging and predatory gulls. Deprived of fishery discards and offal, gulls were further food-stressed by cold-water induced delays of the inshore movements of capelin, the primary forage fish of the NW Atlantic vertebrate food web. Consequently, gulls intensified predation pressure on kittiwakes and puffins, with the former being both food- and predator-stressed. The gulls' breeding success has been poor and indications are that populations are decreasing. Changes in seabird diets in the 1990s provided initial indications of cold-water induced shifts in pelagic food webs over the Newfoundland Shelf. Oceanographic changes and perturbations appear to influence the migratory and vertical movements of pelagic and forage fishes and invertebrates, indirectly affecting seabirds in the process, and changes in seabird ecology associated with oceanographic influences are exacerbated by fisheries activities. Clearly, basic understanding in marine ecology, as well as management strategies involving marine resources, must integrate biophysical interactions.

SOURCES OF INTRACLUTCH EGG-SIZE VARIATION IN THE COMMON TERN

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In species that exhibit brood-size adjustment, last-laid eggs are assumed to be relatively small to facilitate brood reduction. Alternatively, intraclutch egg-size variation (ICESV) may be a function of ambient temperature during clutch formation. We examined the pattern of ICESV in Common Terns breeding near Hamilton, Ontario over 5 years (1992, 94-97). Both the size of eggs laid and the pattern of ICESV varied across years. In 1992, eggs were relatively large with the second-laid egg being largest. In 1994, eggs were relatively small and the last-laid egg was disproportionately smaller than the rest of the clutch. In other years, egg size decreased linearly with laying order. The period prior to egg-laying was mildest in 1992, conditions were moderate in 1994, while the other years were colder, windier and wetter. Within years, weather during the period of clutch formation was related to egg size: larger eggs were produced when conditions were warmer and calmer/drier. Environmental conditions during egg formation may affect egg size by (1) directly affecting female metabolic costs, (2) affecting foraging conditions and therefore the availability of resources for egg formation, and (3) by serving as a predictor of conditions during chick-rearing, information which females use to optimize the size of the eggs they lay. Our data suggest that all three mechanisms may be influencing egg-size variation in this species.

IMPACT OF THE 1997/98 EL NIÑO ON PELAGIC SEABIRDS IN THE NORTHEAST PACIFIC

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Seabirds may be constrained to reside in specific oceanic regions on the basis of marine characteristics; large-scale events that alter those characteristics should produce changes in seabird community consistent with water-mass alterations. Because the factors that constrain

seabirds to particular water-masses are poorly understood, it is difficult to predict their response to changing conditions. In May 1996 I began monitoring seabirds along a repeated 1500km route to Ocean Station Papa. Six surveys were conducted (May, August '96, February, June '97, February, June '98). I expected that the El Niño influenced warming of coastal waters, depression of the thermocline, and northward displacement of the Subarctic Boundary would dramatically alter the seabird community. The results were not entirely as predicted. In support of my predictions, early summer densities (and species number) were lowest in June '97; and species associated with the shelf (Common Murre, Cassin's Auklet, Rhinoceros Auklet) were absent from the June '97 survey. However, confounding observations include: shearwater and Leach's Storm-petrels densities in June '98 surpassed long-term summer averages while densities of most other species remained depressed; and species number (in June '98) returned to pre-El Niño levels, despite the persistence of elevated water temperatures. Preliminary analyses of early summer seabird densities with water parameters (salinity, temperature, nitrate, chlorophyll-a) failed to demonstrate significant correlations. Suggest that water-mass characteristics elsewhere play a major role in shaping local seabird community, and a time lag exists between changing water-mass conditions and response by local seabirds.

EXPERIMENTAL RELEASE OF OIL-SPILL REHABILITATED AMERICAN COOTS (*FULICA AMERICANA*): EFFECTS ON HEALTH AND BLOOD PARAMETERS

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The Unocal-Metrolink oil spill of February 21, 1995 resulted in approximately 7800 barrels of San Joaquin crude oil being deposited into the San Gabriel River in Huntington Beach, CA. In order to determine long-term pathological effects of oil exposure and rehabilitation, hematological and serum biochemical parameters for both rehabilitated (RHB) American coots (*Fulica americana*) and reference (REF) coots were examined every 3-4 weeks (56d, 81d, 108d and 140d post oil exposure) after birds were cleaned, rehabilitated and released. Most significant differences in monthly comparisons between RHB and REF birds occurred within 56 days of oil exposure. Total white blood cell count (WBC), albumin:globulin (A:G) ratio and calcium concentration were higher in RHB birds compared to REF birds 56d post oil exposure. In addition, mean cell hemoglobin (MCH), mean cell hemoglobin concentration (MCHC), alkaline phosphatase (Alk Phos), alanine aminotransferase (ALT), aspartate aminotransferase (AST) and creatine kinase (CK) activities; and creatinine, total protein (TP) and globulin concentrations were lower in RHB birds.

Blood results from 56d post oil exposure for RHB coots which subsequently died were compared to blood results from days 108 and 140 for REF coots which survived. Oiled and rehabilitated birds which died had significantly higher WBC, packed cell volume, TP and globulin concentrations; and lower A:G ratio, MCH, MCHC, glucose and Na concentrations compared to REF birds which survived.

Blood result differences detected at 3-4 week intervals between RHB and REF survivors, and differences detected between RHB coots which died and REF coots which survived, suggested that RHB coots developed an inflammatory response (infectious or non-septic), and concurrently, may have experienced decreased immune responsiveness. Additionally, RHB coots experienced either an iron utilization or iron metabolism problem. These pathophysiological mechanisms were consistent with increased hemosiderin (stored iron) was present in the liver, spleen and kidney of necropsied RHB birds, and may have contributed to RHB coot mortality.

When blood parameter differences were examined for their impact on survival time, it was determined that RHB coots had shorter survival times if they had very high cholesterol (≥ 449 mg/dl) or Cl (≥ 110 MEQ/L) concentrations on day 56 post oil exposure. Interestingly, the lack of differences between RHB and REF coots from day 81 through day 140 suggested that, from a hematologic and clinical chemistry perspective, coots which were oiled, rehabilitated, released and survived at least 3.5 months could not be differentiated from wild (REF) coots. From these findings it appears that blood analysis, coupled with post-release survival data, may help discern reasons for increased mortality of oiled and rehabilitated birds, compared to non-oiled reference birds.

FORAGING AND MORPHOLOGICAL DIFFERENCES BETWEEN KITTLITZ'S AND MARBLED MURRELETS

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We studied foraging ecology and its relationship to morphology in two closely related species, Kittlitz's (*Brachyramphus brevirostris*) and Marbled (*B. marmoratus*) murrelets, because casual field observations suggested that the two species exhibited segregation in foraging habitat and that these differences appeared to be accompanied by morphological differences in eye size. In Prince William Sound, Alaska, the two species differed significantly in preferred habitat type and mean secchi depth (an indicator of water clarity). Mean secchi depth was lowest in glacial-affected and glacial-stream-affected waters, which were preferred for foraging by Kittlitz's Murrelets, and was highest in marine-sill-affected and glacial-unaffected waters, which were preferred by Marbled Murrelets. Although feeding frequency in glacial-affected habitats did not differ between the two species, very few Marbled Murrelets occurred in this habitat, whereas the highest densities of Kittlitz's Murrelets occurred there. We examined eye morphometrics from a sample of museum specimens in an attempt to explain this ecological differentiation. Mean proportions of total skull length and of total post-bill skull length occupied by the orbit diameter were significantly greater in Kittlitz's Murrelets than in Marbled murrelets. These results suggest ecological differentiation in use of foraging habitat by the two species, with Kittlitz's Murrelets adapted to foraging in highly turbid water near glaciers and Marbled Murrelets adapted to foraging in clearer water away from glaciers. These differences in foraging habitat and water clarity probably have led to the differences in relative eye size between the two species.

ADJUSTMENTS OF THE BODY COMPONENTS TO CONTRASTING ENERGY BUDGETS IN INCUBATING AND CHICK REARING RHINOCEROS AUKLETS

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Seabirds rely on their body fuel reserves when coming ashore on land for breeding, particularly at the time of incubation. In contrast to this period, the period of chick rearing is a time of very high energy demand. It would expect that they cope with different energy budgets between breeding stages by the adjustments of body components. This study was carried out at Teuri Island in 1996 summer. To examine the body composition and mass of digestive organs, forty Rhinoceros Auklets were sacrificed under the permission form the Minister of Environment. The breeding birds lost their body mass throughout the breeding season. The mass losses were accompanied with loss of lipids and leg muscles. But wet mass of breast muscles and internal organs did not differ between the breeding stages. In nutritional conditions of breast muscles, mass of protein and ash were larger but lipids were smaller for the birds rearing chicks than for those incubating. Water contents did not differ between the breeding stages. These facts suggest that body components of the breeding birds seem to adjust to the different energy budget.

METAPOPULATION AND GENETIC STRUCTURE OF ASHY STORM-PETRELS, *OCEANODROMA HOMOCHROA*: A POPULATION VIABILITY ANALYSIS

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The Ashy Storm Petrel is a rare species (10,000 or fewer breeding individuals, world-wide), whose breeding is confined to islands off the Central and Southern California coasts. To help design conservation and management plans for this federally-designated Species of Concern, we carried out a population viability analysis (PVA) of this species. The PVA assumed individual subpopulations linked by restricted dispersal, i.e., a metapopulation. Genetic information for the model was obtained by analyses of mitochondrial DNA cytochrome b and control region. These results indicated that populations on Southeast Farallon Island and Santa Barbara Island are not genetically distinct and are likely of recent origin (6,000 years or less). It was not possible to estimate current rates of gene flow between the two populations; the data are consistent with low dispersal rates among populations. The PVA incorporates environmental and demographic stochasticity as well as available information on survival of adults and immatures, reproductive success, and age of first breeding. We use the PVA to project future population trends under different scenarios (e.g., change in management, change in the environment) and to evaluate sensitivity of results to small changes in the various demographic parameters (including survival, reproductive success, and dispersal). We also estimate probability of extinction in the next 100 years, as a basis for considering whether the Ashy Storm Petrel should be designated a Threatened species.

RESPONSE OF SEABIRDS TO CHANGES IN THE CALIFORNIA CURRENT, 1985-1997

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Since the early 1950s, the California Current has exhibited a long-term increase in sea-surface temperature and greater stratification of the upper water column. In turn, the upwelling of deep, nutrient rich water has lessened with a concomitant decrease in primary production and macrozooplankton biomass (e.g. McGown et al. 1996). In response, overall abundances of

seabirds, at the top of trophic levels, have declined by 40%, mainly due to the 90% decrease in the numerically dominant Sooty Shearwater (e.g. Veit et al. 1997).

We present information on seabird abundances in waters off central California collected on annual cruises, 1985-1997. The abundance and distribution patterns exhibited, in response to the changed ocean conditions, differed by species, as exemplified by the three most abundant species, Sooty Shearwater, Common Murre and Cassin's Auklet. Responses were related to differing life histories, morphologies and feeding habits. The shearwater moved out of the system, the murre moved inshore, and the auklet — the only true zooplanktivore — showed a crash in population size.

THE EFFECT OF AGE AND GENDER ON THE ADRENOCORTICAL RESPONSE TO STRESS IN LEACH'S STORM-PETRELS

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We examined the adrenocortical response to capture and handling stress in a breeding population of Leach's Storm-petrels (*Oceanodroma leucorhoa*) at Kent Island, New Brunswick in 1996 and 1998. Acute elevation of corticosterone has been associated with gluconeogenesis, increased feeding behavior, and "escape" behavior. However, chronic elevation of corticosterone inhibits reproductive behavior and immune function. Because an elevated stress response may enhance survival at the expense of reproduction, we expected younger birds to have a higher stress response than older birds. The stress response, as measured by the increase in plasma levels of corticosterone between 3 and 30 min after capture, was negatively correlated with age in 1996 ($p < 0.01$), but not in 1998 ($p = 0.29$). In 1998, older individuals (≥ 15 years old) that were handled more often ($> 75\%$ of the number of seasons since first banded) did not have a significantly different stress response than individuals that experienced less frequent handling ($< 60\%$ of the number of seasons since first banded). Baseline levels of corticosterone (obtained within 3 min of capture) were positively correlated with age in both years ($p < 0.01$). Males and females had similar levels of corticosterone in response to capture stress, as predicted since both sexes have equal and obligate parental care.

MARbled MURRELETS AS INITIATORS OF FEEDING FLOCKS IN PRINCE WILLIAM SOUND, ALASKA

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I sought to determine which seabird species initiated small, ephemeral, multispecies feeding flocks in Prince William Sound, AK (PWS), by observing the formation of flocks at sites known to have frequent feeding aggregations. I observed 43 feeding flocks at 5 sites during June 1996 and determined the initiating species at 34. All of the observed flocks were initiated by pursuit divers, of which 76.5 % were Marbled Murrelets (*Brachyramphus marmoratus*), the most abundant seabird in PWS. Formation of feeding flocks followed either of 2 scenarios: 1) larids were attracted to a feeding location by the presence or activity of Marbled Murrelets or 2) both larids and murrelets were present and flock feeding began after the murrelets dove from the

surface. Of the observed flocks, 26.9 % and 50.0 % were initiated under scenarios 1 and 2, respectively. Other principle participants were Black-legged Kittiwakes (*Rissa tridactyla*) and Glaucous-winged Gulls (*Larus glaucescens*). I observed an apparent commensal relationship between murrelets and larids at feeding flocks with larids being the beneficiary.

SEABIRD BY-CATCH AND THE CONSERVATION TRAP: BLIND OR CRYING WOLF

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Inadvertent capture of charismatic megafauna in marine fisheries has provoked public outrage, finger pointing and political maneuvering, leading to a rush to regulate with or without solutions. Regulations have included modification of gear and/or procedures, time and area restrictions, and quota reductions. In certain cases, fisheries are threatened with closure. Can these measures be justified on conservation grounds? Although many studies of seabird by-catch quantify seabird fishery mortality, few link that mortality to declines in specific populations. Conversely, studies documenting population declines rarely parse out causality. The wide range of seabird distribution, the size, spatial and seasonal range of fisheries, the rarity of by-catch events, the frequency and quality of seabird population studies, and the inherent lag in measurable demographic effects in long-lived species all frustrate the linkage of effect and cause the conservation trap. This may lead to two problems: 1) Crying Wolf: asserting that there is a problem when one does not exist, or 2) Being Blind to the Obvious: failing to recognize a serious conservation problem when it in fact exists.

SEABIRD AND MARINE ECOSYSTEM RESPONSE TO CLIMATE VARIABILITY IN ALASKA

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Marine climate in the NE Pacific fluctuates at four dominant time scales: 2-3 years (Quasi-Biennial Oscillation, QBO), 5-7 years (El Niño-Southern Oscillation, ENSO), 20-25 years (Bi-decadal oscillation, BDO), and 50-75 years (very low frequency oscillation, VLFO). Since the 1850's, marine climate has flip-flopped 13 times between "cool" and "warm" states. The duration and magnitude of these states depend on whether oscillations are in phase or not. Both QBO and ENSO effects are evident on seabirds in Alaska, but effects are transient, localized, and appear to have little long-term effect on seabird populations and marine ecosystems. VLFO effects cannot be evaluated from existing data, except to the extent that when VLFO oscillations are in phase with BDO oscillations, they have more impact on marine climate and ecosystem structure. Decadal oscillations have the greatest measurable impact on seabird populations; mediated through persistent effects on food supplies. Cold regimes favor a variety of important forage taxa (e.g., shrimp, capelin, herring, Atka mackerel) while warm regimes favor large predatory fish (arrowtooth flounder, halibut, pollock, cod, salmon) that compete directly with seabirds for prey. The mechanisms by which decadal-scale changes in climate affect marine food webs are unclear. The "match-mismatch" hypothesis may best explain inter-specific differences in fish recruitment and long-term changes in fish and seabird populations observed in the Gulf of Alaska during the past 45 years.

IMPACTS OF AVIAN PREDATION ON FISHERIES AND RECOVERY OF ESA LISTED SALMON IN THE COLUMBIA RIVER BASIN

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Colonies of Caspian terns and double-crested cormorants nesting on man-made islands in the Columbia River Estuary have expanded rapidly in the past 15 years. Caspian terns that first nested in the estuary in 1984 now number 10,000 pairs. Cormorant colonies have increased from a few hundred pairs to 7,000 pairs in the same period. Concurrently, many salmon populations have become listed under the Endangered Species Act. A research project on avian predation impacts estimates up to 30 million juvenile salmon smolts are consumed annually by the bird colonies. The smolts consumed by birds represent up to 400,000 lost adult returns worth many millions of dollars to tribal, recreational and commercial fisheries. Evidence is presented that up to 3 million of the smolts lost to predation are listed under the ESA and represent 30,000 adults that will not return to spawn. Although there are other factors in the decline of anadromous fish of the Columbia Basin, avian predation may be the most serious problem for some listed stocks.

CORRELATING FOREST HABITAT DISTRIBUTION WITH MURRELET RADAR COUNTS: IS THERE A CONNECTION AT THE DRAINAGE SCALE?

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The amount, configuration, and availability of suitable nesting habitat has been proposed to influence the number and distribution of marbled murrelets (*Brachyramphus marmoratus*) during the breeding season. Long-term monitoring of this threatened species likely will occur on a broad scale, and reliable methods to track changes in murrelet populations and habitat need to be developed. We tested whether the amount of potential nesting habitat within drainage predicts numbers of murrelets entering that drainage. Using radar, we estimated murrelet numbers in 9 river drainages on the Olympic Peninsula, Washington, during late June and July 1998. Each site was sampled 2-3 consecutive days. Total area of drainages ranged 14,600 to 75,700 ha, and included 30-60% of late-seral habitat as classified from satellite imagery. We compared the mean count of inland-bound murrelet targets to the amount of late-seral habitat within drainage boundaries. Number of murrelets detected with radar generally was positively but weakly associated with the amount of late-seral habitat within the drainage. We discuss the implications of these findings to long-term monitoring strategies and we propose improvements in study design that might lead to more robust conclusions.

FEEDING AREA OVERLAP AMONG ADELIE PENGUIN COLONIES: A TEST OF POPULATION-REGULATION MODELS

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Furness and Birkhead's (1985) "Hungry Horde Model" proposes that colony size is regulated by

competition for food in common foraging grounds within foraging range of one another during the chick provisioning period. Cairn's (1992) "Hinterland Model" predicts that neighboring seabird colonies should occupy non-overlapping foraging areas, and that seabirds should feed closer to their own colony than any other. These models remain largely untested.

Using radio-telemetry in two summers, we defined foraging areas among Adelie Penguins at 4 colonies within one isolated colony cluster in the southern Ross Sea. Longest foraging trips indicated that penguins from each colony were capable of foraging within the range of all the others. Penguins from Capes Bird and Royds on Ross Island, and those from Beaufort Island — all small to medium-sized colonies — overlapped foraging areas extensively. In contrast, the foraging area of penguins from Cape Crozier, a colony larger than the other three combined, abutted that of the others with no overlap. Crozier penguins supported the Hinterland model, but the others supported the Hungry Horde model. Whether competition was taking place in overlapping areas, in further support of Hungry Horde, is unknown. Intriguing was the fact that Crozier penguins fed right to the western shore of Beaufort Island, with Beaufort penguins feeding, without overlap, immediately off the eastern shore. Were the Beaufort birds avoiding the much more numerous Crozier birds?

SAND LANCE: HOW THEIR BIOLOGY IMPACTS PREDATORS AND RESEARCHERS

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Sand lance (*Ammodytes hexapterus*) are an important forage fish for many Gulf of Alaska and Bering Sea predators. Significant biological changes have occurred in this area as a result of climate change since the late 1970s. However, the unique biology of sand lance has allowed their abundance, and hence availability to predators to remain relatively stable. Fat reserves of adults are established during spring plankton blooms. Correspondingly, energetic value increases over 30% by July, allowing chick-rearing seabirds to utilize peak condition sand lance of about

21kJg⁻¹ (dry). Subsequently, they remain buried for increasing periods in shallow substrates, as energy reserves are utilized for maturation and spawning in October. Consequently, sand lance represent a relatively low-value winter prey source compared to other forage fish which maximize energetic value in winter such as capelin (*Mallotus villosus*). Juvenile sand lance recruit to nearshore areas in May, and become the dominant taxa by late August. Somatic growth is rapid, followed by increases in energetic value, which peak at 20kJg⁻¹ (dry) in September. Therefore, juveniles may provide an abundant and energetically rewarding pre-winter prey source for predators. Back-calculations of sand lance size from otoliths need to consider that single regressions are rarely adequate in describing the otolith/fish length relationship. Sand lance exist in distinct populations, which live, spawn, and develop in conjunction with specific nearshore substrates, making them highly vulnerable to habitat degradation (e.g., oil or physical disruption).

WHAT TO DO WITH THE WORLD'S LARGEST CASPIAN TERN COLONY: WHEN ESA COLLIDES WITH MBTA AND NEPA IN THE COLUMBIA RIVER ESTUARY

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Caspian tern predation rates on juvenile salmonids in the Columbia River estuary are astonishingly high. In both 1997 and 1998, estimates of the number of salmon smolts consumed by terns nesting on Rice Island (an artificial dredge disposal island) were 6-27 million, or 5-25% of all out-migrating salmonids that reached the estuary. Most Columbia Basin salmonid stocks are ESA-listed, but terns eat mostly hatchery-raised smolts. Caspian terns first nested in the Columbia River estuary in 1984; in 1998 the Rice Island colony numbered over 20,000 individuals, apparently the largest colony of its kind in the world. The colony coalesced from former colonies and now represents over 75% of all Caspian terns breeding along the Pacific Coast, and 25-30% of the North American population. The magnitude of smolt losses to Caspian terns in the Columbia River estuary results from (1) availability of nesting habitat on dredge spoil islands, (2) abundant and readily-captured prey, (3) loss of tern nesting habitat elsewhere due to human activities, and (4) declines in alternative fish prey. Redistribution of the Rice Island Caspian tern colony to a number of former and new breeding sites may benefit both terns and salmonids alike.

BENEFITS OF HIGH-FAT FOODS FOR NESTLING SEABIRDS

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Piscivorous seabirds consume prey that vary widely in fat content, but the potential benefits of selecting fatty prey to feed growing nestlings are poorly understood. We compared the digestive organs, fat reserves, and energy assimilation efficiencies of Black-legged Kittiwakes raised in captivity on different controlled diets. Nestlings were fed diets of either different lipid content but similar daily caloric intake, or similar lipid content but different daily caloric intake. Size of gizzard, proventriculus, and pancreas were most dependent on daily biomass intake, whereas size of small intestine was most dependent on daily caloric intake. Fat reserves were dependent on both daily caloric intake and lipid content of the diet. Body mass was not highly correlated with total fat content of individual birds, suggesting that body mass alone may not be a good predictor of fledgling energy reserves. Apparent assimilation efficiency for dietary energy was higher on high-lipid diets, but was not affected by large differences in daily caloric intake. The results indicate that kittiwake nestlings can be almost 20% more efficient at assimilating energy on high-lipid diets compared to low-lipid diets, even when daily caloric intake is the same. Kittiwake nestlings fed high-lipid forage fish benefit from reduced requirement for food biomass, reduced allocation to visceral organs, higher energy assimilation efficiencies, and larger fat reserves at fledging.

HOW SEABIRDS FIND FOOD AT SEA

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How seabirds find food at sea is often not apparent. For example, in the Bering Sea, Least Auklets (*Aethia pusilla*) fly up to 100 km from their breeding colonies to feed on calanoid copepods, which are obtained by underwater pursuit in waters that appear strikingly homogeneous to shipboard observers. Previously we hypothesized that Least Auklets and other seabirds exploit fractal resource landscapes (such as plankton distributions) using a multiscale search strategy, whereby individuals employ area-restricted search tactics to move up local resource density gradients toward fine-scale prey concentrations, but rely on visual observations of other foraging birds as cues to locate potentially more profitable prey concentrations at larger scales. In this study, we tested predictions of the model during cruises around the Aleutian Islands in two years. We found that fine-scale spatial correlations between auklet density and acoustically measured plankton biomass increased with increasing regional auklet abundance and decreased with increasing fractal dimension of the prey distribution (i.e., indicating more complex patterns). We suggest that an ensemble of foraging seabirds behaves as a massively parallel, self-organizing information-processing system. Seabird colonies may therefore be characterized in part as complex adaptive systems for foraging

ADVECTIVE CONTROL OF ANTARCTIC KRILL-BASED FOOD WEBS

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The factors underlying extreme fluctuations in krill distribution and abundance, and their consequent impacts on krill predators, have become an important focus of Antarctic marine ecology. Using a time series of bottom pressure anomalies from the continental slope north of the Antarctic Peninsula, we demonstrate that interannual fluctuations in krill abundance in the Elephant Island region are significantly related to an index of potential advective input of krill to the region via passive transport in currents. Results from a 6-year study of Chinstrap Penguins (*Pygoscelis antarctica*) — the principal krill predators in the Elephant Island region — suggest that 1) breeding population size and reproductive performance were affected by variation in advection of prey to their summer foraging grounds during the spring pulse of the Antarctic Circumpolar Current (ACC), and 2) the early-season condition of breeding penguins was affected by the extent to which their winter foraging grounds were replenished with advected krill during the preceding autumn ACC pulse. These findings support a prominent role for oceanic advection in Antarctic krill-based food webs.

PROBLEMS WITH PIRATES: TOOTHFISH LONGLINING AND SEABIRD BY-CATCH AT THE SUB-ANTARCTIC PRINCE EDWARD ISLANDS

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Longlining for Patagonian Toothfish in the South African Exclusive Economic Zone around the sub-Antarctic Prince Edward Islands commenced in 1996. Seabird by-catch data were obtained from observers aboard 21 sanctioned fishing trips (7.5 million hooks), during 1996-1998. 1421 birds of 10 species were reported killed. White-chinned Petrels (*Procellaria aequinoctialis*) predominated; with large numbers of giant petrels (*Macronectes* spp.) and mollymawks (*Thalassarche* spp.). Most were male breeding adults. Average seabird by-catch rate in 1997-98 was 0.117 birds per 1 000 hooks, less than half that (0.289) reported in 1996-97. More than 1% of four local breeding populations were killed during the 1996-97 season. Low reproductive rates mean these levels of mortality are not sustainable, resulting in local population declines. The greatest improvement in bycatch relative to 1996-97 was among mollymawks, due to a decrease in daytime setting and increased use of streamer lines. Despite considerable improvements relative to the 1996-97 season, further efforts are needed to ensure that fishers adhere to permit conditions. The fishery should be closed during February to mid-March when White-chinned Petrels are caught in greatest numbers. Mortality from the unsanctioned (illegal and unregulated) fishery is the gravest concern, since it involves roughly 10 times more effort than the sanctioned fishery and almost certainly has a greater bird by-catch rate.

CONTRASTING PATTERNS OF REPRODUCTIVE SUCCESS FOR TUFTED PUFFINS AND RHINOCEROS AUKLETS IN BRITISH COLUMBIA: 1975-1998

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Should two closely related alcids respond to long term changes in the marine environment in a similar manner? To address this question we compared nestling growth, productivity and diet for the diurnally active Tufted Puffin and the nocturnally active Rhinoceros Auklet breeding on Triangle Island, B.C. using current and historical data. Both species exhibit a decline in breeding success from 1975-1998, and values for TUPU have been consistently lower than for RHAU. TUPU have virtually failed to produce any fledglings from 1994-1998. In addition, chick growth rates of both species have declined since the 1970s. Concurrently, there has been an overall decline in the proportion of Sand lance in the diet of nestlings of both species. During the 1990s Sand lance consistently disappeared from the RHAU nestling diet from mid to late July in each year. In the absence of Sand lance, RHAU switched to alternative prey species such as Pacific Saury, Pacific Herring, Salmonids and Rockfishes. In contrast, TUPU did not exploit the same range of alternative prey and breeding failure thus coincided with the timing of absence of Sand lance from nestling diets. TUPU may be unable or unwilling to provision their chicks with alternative prey species of sufficient quantity or quality when Sand lance appear unavailable. We postulate that the interspecific differences in nestling diet and breeding success may reflect foraging constraints imposed by the diurnal provisioning habits of the TUPU which do not affect the nocturnal RHAU.

INTERANNUAL VARIABILITY IN THE REPRODUCTIVE SUCCESS OF PIGEON GUILLEMOTS NESTING ON JACKPOT ISLAND, IN SOUTHWESTERN PRINCE WILLIAM SOUND, ALASKA, 1994-1998.

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Since the 1989 Exxon Valdez oil spill (EVOS), the population of pigeon guillemots, *Cephus columba*, in Prince William Sound, Alaska, have shown no growth. We studied the breeding biology and nestling diet of pigeon guillemots at Jackpot Island, from 1994 to 1998, to examine factors that may be limiting population growth at colonies not directly oiled by EVOS. Between 1993 and 1998, the Jackpot Island colony increased from 79 birds to 101 birds. Annual productivity from 1994 to 1998 was 0.61, 0.25, 0, 0.17, and 0.18 fledgling/egg, respectively. Nesting efforts failed in 1996 because of catastrophic mink predation on the island. In the other four years of our study, nest predation was low (6% of the nests). The 1994 breeding season was noted for having the lowest nest abandonment rate during incubation, 21%, the highest mean growth rate of nestlings aged 8-18 days, 20.3 ± 3.5 g/day, and highest mean fledge (± 2 days) mass, 508 ± 37 g, during our five year study. Nest abandonment rates, mean (\pm SD) growth rate and mean (\pm SD) fledgling mass, respectively, were 34%, 17.1 ± 2.8 g/day, 467 ± 39 g in 1995; 48%, 18.6 ± 7.0 g/day, 472 ± 41 g in 1997, and 61%, 18.8 ± 3.4 g/day, 482 ± 42 g in 1998. Thus compared to 1994, lower productivity and higher nest abandonment in 1995, 1997 and 1998 were associated with lower growth rates and lower fledge weights. These associations suggest that higher rates of nest abandonment in 1995, 1997, and 1998 may have been caused by food limitation during the incubation period as reflected by the subsequent decline in growth rates and fledge weights of surviving nestlings in those years.

ASSESSING POPULATION STATUS AND MONITORING REPRODUCTIVE SUCCESS OF THE CHRISTMAS SHEARWATER (*PUFFINUS NATIVITATUS*) ON EASTERN ISLAND, MIDWAY ATOLL NWR

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The Christmas Shearwater (*Puffinus nativitatis*) can be found in small populations scattered throughout the Central Pacific Ocean, including Midway Atoll NWR, Northwestern Hawaiian Islands. Black rats were introduced to Midway Atoll in 1943. After its introduction, nesting populations of several ground-nesting Procellariiformes declined rapidly or were extirpated. The population size of the Christmas Shearwater and impact of rat predation had never been assessed prior to 1995. In 1994, rats were eradicated from Eastern Island. In 1995, a three year study was initiated on Eastern Island to assess the population status and monitor the reproductive success of the Christmas Shearwater after rat eradication. This study involved repeated searches in historical nesting areas under dense *Scaevola sericea* bushes, a succulent shrub commonly found on coastal islands in the Pacific. Results indicated a surprisingly higher breeding population than estimated in the past. In 1995, a total of 99 active nests were monitored with 69% hatching success, 87% fledging success, and 60% reproductive success. After discovering the high number of nests in 1995, the study was intensified to search the entire island for nesting birds. In 1996, a total of 179 nests were monitored with 53% hatching success, 79% fledging success, and

41% reproductive success. In 1997, 194 nests were monitored with 78% hatching success, 79% fledging success and 62% reproductive success. A total of 695 breeding and non-breeding adults and 213 chicks were banded during the three year project.

CONSERVATION GENETICS OF BLACK-FOOTED ALBATROSSES: THE ORIGIN OF BYCATCH BIRDS

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Hundreds of thousands of procellariiformes such as Black-footed Albatrosses (*Diomedea nigripes*) are caught every year in longlines spread over the world's oceans. However, for many such species, modeling the demographic impact of longline fisheries is problematic because the precise population sources and population structure of bycatch birds are unknown. To determine the population sources of Black-footed Albatrosses caught in longlines in the North Pacific, we analyzed mitochondrial DNA sequences amplified from tissue samples associated with albatross specimens caught at sea and deposited in the Burke Museum, and compared these to sequences amplified from blood obtained from birds in the two principal breeding areas, Hawaii and Japan. In a 356-bp segment (region I) of the hypervariable control region, we found that the Hawaiian birds (n = 16) exhibited almost six times the level of sequence diversity as birds from Torishima Island, Japan (n = 18). A phylogenetic analysis indicates that the Japanese birds may have been founded by Hawaiian colonists and that the majority (n = 9; 82%) of birds caught in longlines originate from Hawaiian populations, a result consistent with banding data. However, two bycatch birds (18%) possibly originate from Japanese colonies, a rate considerably higher than suggested by banding data. These results suggest that the precision and conclusions of demographic modeling of the impact of longline fisheries on Black-footed Albatross populations can benefit from information on source-sink dynamics gleaned from genetic studies.

USE OF RADAR TO MONITOR MARBLED MURRELETS IN THE SANTA CRUZ MOUNTAINS, CALIFORNIA

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A pilot study was conducted using ornithological radar to track and monitor Marbled Murrelets (*Brachyramphus marmoratus*) in four drainages in the Santa Cruz Mountains, California. The Santa Cruz Mountains are the southernmost murrelet breeding area and support the smallest and most isolated population of the Marbled Murrelet. Our primary monitoring site, Gazos Creek Canyon, is typical of coastal canyons in the Santa Cruz Mountains — steep and narrow with a dense cover of coast redwood, and separated from the coast by a marine terrace covered with grassland or chaparral. Although radar has been successfully used to detect murrelets in other terrains, this technique had not been used in the unique terrain found in the Santa Cruz Mountains. Through careful selection of station locations we were able to successfully use radar to monitor murrelets traveling to and from their breeding areas. Radar stations we used included grassy knolls at the mouth of forested canyons, canyon bottom meadows, hillside openings, and ridge top locations. We discuss the criteria for suitable radar survey sites and the parameters affecting the detection of murrelets by radar. We describe some new tools that maximize data

from murrelet radar surveys and reduce identification errors. Our findings indicate that radar is the ideal tool for locating murrelet breeding areas in the Santa Cruz Mountains and for monitoring changes in the number of murrelets using those areas over time.

SAINT LAZARIA SEABIRDS: DO THEY TELL US ABOUT CHANGES IN THE MARINE ECOSYSTEM IN SOUTHEAST ALASKA?

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Leach's and fork-tailed storm-petrels, glaucous-winged gulls, and common and thick-billed murres and rhinoceros auklets were among the seabird species studied at St. Lazaria Island from 1994-1998. These birds cross a range of feeding guilds (planktivores, opportunists and piscivores, respectively), effectively sampling widely from the marine environment. As food availability changes the health of seabirds, their reproductive health is ultimately affected. Therefore, we monitored several parameters of reproductive output by these seabirds to try to detect changes in the marine environment. Direct sampling of environmental conditions were limited, but nearshore water temperatures were collected to detect within-season changes. Overall productivity of glaucous-winged gulls and murres fluctuated most throughout the study period while productivity in the remaining species changed little. Further results including breeding phenology and food habits are presented in this paper.

EFFECTS OF THE 1997-98 EL NIÑO ON ANCIENT MURRELETS IN HAIDA GWAI

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In 1998, one of the strongest El Niño - Southern Oscillation events in 15 years affected sea conditions throughout the northeast Pacific. To assess the effects of the 1998 El Niño on seabirds in Haida Gwaii (Queen Charlotte Islands), we examined long-term monitoring data relating to Ancient Murrelets in the Laskeek Bay area: East Limestone Island (1990 - present) and Reef Island (1984-89, 1995, 1997). For the first time in ten years of study, half of the breeders deserted their eggs. Breeding success fell by 43 percent from a mean of 1.54 chicks/burrow over 1988-97 to 0.88 chicks/burrow in 1988. Adults weighed at the end of incubation were found to be lighter than in previous years. Although egg laying was initiated within the usual dates, the spread of chick departures was greater than normal despite fewer chicks produced. However, there was no difference in either egg volume or median chick departures among years. Mean counts of Ancient Murrelets on the gathering grounds were significantly different among years, with 1998 among the highest in nine years. During coastline surveys, we also found the greatest numbers of Marbled Murrelets since 1993, also an El Niño year. We suggest that El Niño induced oceanic conditions caused reduced breeding success in Ancient Murrelets, the effect being more marked than for any event since at least 1988.

MIGRATION ROUTES OF SOOTY SHEARWATERS IN THE PACIFIC OCEAN

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During 17 cruises, 1983 to 1991, we recorded flight directions and densities of Sooty Shearwaters (*Puffinus griseus*) migrating across the equatorial Pacific, between the Americas and 170°W. Sooty Shearwaters breed in New Zealand and Chile in boreal winter, migrate to the North Pacific during spring, and return south in autumn. A two-fold increase in numbers flying northwest from the Peru Current in spring compared to the number fly southeast on return in autumn, and six-fold increase in numbers flying southwest towards New Zealand during autumn, compared to the number migrating northeast during spring, indicates that many completed a figure-eight route (ca. 40,500 km) each year. This route would involve easterly flight from New Zealand to the Peru Current in winter, northwesterly flight to the western North Pacific in spring, eastward movement to the eastern North Pacific during summer, and southwest flight to New Zealand during autumn. We suggest that most shearwaters using this route are nonbreeders, possibly from both the New Zealand and Chilean populations. Many birds, probably breeders, likely use shorter routes to and from the North Pacific (ca. 28,000 to 29,000 km). A progressive annual increase in the number migrating to the North Pacific, concurrent with a progressive increase in sea-surface temperature, mostly reflected increased migration from the Peru Current. This also was consistent with a concurrent sharp decline of these birds in the California Current. These results indicate a distributional shift during the nonbreeding period, from the eastern boundary currents to the central North Pacific.

SEABIRD BYCATCH IN LONGLINE FISHERIES OF ALASKA

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Seabird bycatch is a serious conservation issue in Alaska and in other regions of the world. Over 10 species of seabirds are being incidentally caught in groundfish and halibut longline fisheries in the Bering Sea/Aleutian Islands and Gulf of Alaska fishery regions. The total estimated average annual mortality of seabirds in the Alaskan longline groundfish fishery was almost 14,000 birds between 1993 and 1997 with about 85% of the total occurring in the Bering Sea/Aleutian Island region. The average bycatch ranged from a low of about 9,300 birds in 1993 to a high of about 20,200 birds in 1995. The bycatch of Northern Fulmars represented about 66% of the total bycatch while Laysan and Black-footed Albatrosses accounted for about 5% and 4%, respectively, of the total seabird bycatch. During the period of 1993 to 1997 there were 3 endangered short-tailed albatrosses taken in the longline groundfish fishery.

In May 1997, the National Marine Fisheries Service, (NMFS) implemented regulations to require seabird deterrent devices and measures to reduce the bycatch in groundfish longline fisheries in Alaska. In 1998, NMFS also implemented similar regulations for the Pacific halibut fishery off Alaska.

MONITORING NORTH AMERICA'S COLONIAL WATERBIRDS: A COMPREHENSIVE PROGRAM

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Long-term conservation planning and management efforts for Colonial Waterbirds (including pelagic seabirds, gulls, terns, and wading birds) require the collection of species location and population trends over a broad geographic range spanning international boundaries. We are leading a cooperative effort to develop a monitoring program for Colonial Waterbirds in Canada, Mexico, the Caribbean, and the United States. The monitoring program consists of (1) a centralized database located at Patuxent Wildlife Research Center (PWRC) and (2) a set of standardized survey methodologies used voluntarily by wildlife managers throughout North America. The database is easy to use and will be designed to allow researchers, resource managers, and volunteers to input and access data via the Internet. Presently, the database consists of data collected by the U.S. Fish and Wildlife Service's Great Lakes and Atlantic Coastal Colonial Waterbird surveys and data from the Cornell Colonial Waterbird Registry. Through a cooperative effort with individual States in the United States, Canadian Provinces, Mexican States, data from past and present surveys will be incorporated, with an attempt to coordinate with Colonial Waterbird monitoring activities throughout the Caribbean basin. Links to other databases, such as the Pacific Seabird Monitoring database and PWRC's contaminants database, will be developed.

INDIRECT EFFECTS OF THE AVAILABILITY OF FORAGE FISHES AND FISHERIES DISCARDS: GULL PREDATION ON BREEDING STORM-PETRELS

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The Northwest Atlantic has undergone large-scale perturbations which have had profound effects on pelagic food webs. Over the past century, the availability of human refuse and discarded fisheries waste have supported and maintained the growth of Larid gull populations. Recently, cold surface-water events have delayed the inshore movements of forage fishes and fisheries closures have removed massive quantities of discards. These circumstances have interacted to generate intense food stress on gulls. We investigated the indirect effects of prey availability and fishing activities on seabird community interactions. Gull predation on Leach's storm-petrels (*Oceanodroma leucorhoa*) did not differ between forest and open habitats even though gull nests were more often in close proximity to storm-petrels in open areas than in forest habitat. In 1996 and 1997, gull predation on storm-petrels varied seasonally, with a significant decrease following the inshore movement of spawning capelin (*Mallotus villosus*) a primary food that gulls consume and feed to their chicks. Capelin availability was considerably later in 1997, when gull predation on storm-petrels was greater and prolonged. The intensity of gull predation on storm-petrels depends on the availability of alternative food sources.

ALASKA/RUSSIA FAR EAST SEABIRD COLONY CATALOG

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The U.S. Fish and Wildlife Service, Anchorage, Alaska in cooperation with the Institute of Biological Problems of the North, Magadan, Russia combined seabird colony data and created

the Alaska/Russia Far East Seabird Colony Catalog. The Catalog stores current and historical data on breeding population size, species composition, and location data of 1,705 Alaskan and 453 Russian seabird colonies. Forty-six seabird species are listed and colony sizes range from a few pair to 5.75 million birds. The Catalog consists of a relational database program linked to a geographic information system. The author can provide data reports and detailed maps showing colony locations and sizes for any documented species. The Catalog can also be accessed via the Internet (contact the author for the Internet address). Create maps, download data, and view a video or photograph of a colony or seabird species. Additional web pages are dedicated to learn about seabird species, projects, and personnel. We welcome review of existing data and encourage observers to send new data. Updates are made often and suggestions to improve the Catalog are gladly accepted.

THE PACIFIC SEABIRD MONITORING DATABASE — A DESKTOP INFORMATION SYSTEM FOR NORTH PACIFIC SEABIRDS

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A 1992 Pacific Seabird Group survey of past and present seabird monitoring efforts in the temperate North Pacific indicated that upwards of 10,000 observations on seabird population parameters are available for North Pacific colonies. The Pacific Seabird Monitoring Database was developed as a means of making these largely inaccessible data available to potential users in a timely manner. Since 1995, 13 contributors have entered into the database almost 1,900 series and a total 11,693 observations on 56 species that breed in the Pacific north of 20° N. Each observation represents a yearly estimate of a particular population parameter for a given species in a given location. Population size (40 percent of observations) is the most studied parameter included in the data set, followed by components of productivity (25 percent) and reproductive chronology (20 percent). Data exists for locations in Alaska (65 percent of observations), Oregon, Hawaii (16 percent), California (12 percent), British Columbia, and the Russian Far East. With 3,485 observations (30 percent) the black-legged kittiwake (*Rissa tridactyla*) is the single most studied species. The database utilizes a run-time version of Microsoft Access for data entry, editing, querying, reporting and exporting, and includes Geographic Information System databases to be used with ArcView 3.0 for regional database querying, mapping, and spatial analysis capabilities. A test version of the database on compact disk and an instruction manual have been released for peer review. Internet access to the database is anticipated in 1999. This project is a cooperative effort of the Pacific Seabird Group and the USGS-Biological Resources Division, Alaska Biological Science Center.

SEASONAL MIGRATION OF MAGELLANIC PENGUINS: EVIDENCE FROM BAND RETURNS

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Fourteen years of winter band return data for Magellanic penguins (*Spheniscus magellanicus*) indicate that this species may undertake one of the longest seasonal migrations known among non-flying birds, with a one-way distance often exceeding 2000 km. Chicks, juveniles, and

adults banded at a breeding colony in southern Argentina were most commonly found in winter along the coasts of Uruguay and southern Brazil. Distance traveled appears to decrease somewhat with age, but even birds in the oldest age class studied (>3 years) were found more than 2000 km from the colony. The number of bands recovered from dead or moribund birds in the winter following fledging was inversely correlated with subsequent re-sighting rates of live birds in each cohort at the colony, suggesting that mortality during the migration period is a significant determinant of recruitment rate. Survival rate and location of fledglings during migration varied by year, and is likely to be dependent on oceanographic conditions, although this relationship appears to be complex. The great distance of the seasonal migration and the fact that the migration route traverses the waters of three nations present a major challenge in the conservation of this species.

FORAGING ECOLOGY OF BLACK-LEGGED KITTIWAKES IN RELATION TO PREY ABUNDANCE

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We studied nestling diets and foraging activities of breeding Black-legged Kittiwakes during five years (1989-90 and 1995-97) of high to low food abundance at two colonies, Shoup Bay and Eleanor Island, in Prince William Sound, Alaska. Years of low food abundance were associated with increased foraging effort (duration, distance, and travel time) and significant changes in diet (prey switching). Foraging activities and flight paths of radio-tagged adult kittiwakes were recorded while following individuals by boat. Foraging effort was consistently greater at Shoup Bay ($P < 0.05$) with a mean trip duration of 4 hr and distance of 40 km in good food years, increasing to 6 hr and 60 km during a year of low food abundance. Foraging trips of kittiwakes at Eleanor Island averaged 2 hr and 5 km during years of high food abundance and increased to 5.6 hr and 35 km during the worst year. Years of low food abundance were associated with significant declines ($\chi^2 \geq 18.47$, $P \leq 0.001$) of age class one Pacific herring in kittiwake diets. Consequences of reduced herring were greatest at Shoup Bay where alternative prey close to the colony did not exist. Whereas kittiwakes from Eleanor Island compensated for lack of herring by obtaining Pacific sand lance and capelin. Time spent traveling increased with greater trip duration, but search and prey capture time were not directly related to trip duration and may reflect foraging strategies that vary with different species, age classes, or abundance of prey consumed.

SPATIAL AND TEMPORAL TRENDS IN REPRODUCTIVE DYNAMICS OF SEABIRDS IN THE CALIFORNIA CURRENT MARINE ECOSYSTEM: RESPONSE TO EL NIÑO AND LOWER FREQUENCY MARINE CLIMATE CHANGE

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Time series on the reproductive dynamics of storm-petrels, cormorants, pelicans, alcids, and gulls were examined in relation to El Niño and lower frequency marine climate change (i.e., a secular increase in ocean temperatures) to determine the response of seabirds to coastal ecosystem change from the late 1960s to the present. In addition, this study was part of a broader investigation on effects of the 1997-1998 El Niño on coastal ecosystems from southern California through the Bering Sea (funded by NOAA/ERL). Study sites included: Santa Barbara, West Anacapa, and Prince islands in southern California; Ano Nuevo, Alcatraz and Southeast Farallon islands in central California; Yakina Head, Oregon and Tatoosh Island, Washington. As observed during previous El Niño events in the California Current Ecosystem (CCS), there were marked reductions in breeding population size, breeding effort, and reproductive performance and changes in diet composition associated with this El Niño; effects were most apparent in 1998. At Tatoosh Island, due to interactions between murrelets and eagles, and locally high marine productivity, the climate signal was difficult to detect. In general, there was little direct evidence of increased mortality rates amongst adults, although there were a few seabird die-offs during this period. In comparison with other El Niños, the 1998 event was one of the strongest, yet comparative effects varied between species and trophic levels. In southern and central California, effects of this event also must be viewed in relation to declining trends in the reproductive performance for many species since the mid 1980s. Coupled with long-term ocean warming, population-level effects of strong, recurrent interannual warm-water events may be expected. Indeed, breeding populations of many seabird species in the CCS have either ceased growing or declined, some considerably, in recent time.

BASELINE MONITORING AND ASSESSMENT OF EFFECTS OF DISTURBANCE TO BRANDT'S CORMORANTS ON ALCATRAZ ISLAND, CALIFORNIA

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The Brandt's Cormorant colony on Southeast Farallon Island has experienced consistent decline since the 1970's, while in recent years, new colonies have been established at several locations along the California coast. Brandt's Cormorants began breeding on Alcatraz in 1993, creating the only colony for this species in San Francisco Bay. We monitored cormorants on Alcatraz during the breeding seasons from 1996-1998 to establish baseline information on distribution, abundance, productivity, and human-caused disturbances to this colony. Productivity averaged a relatively high 1.90 chicks/pair, despite a high rate of disturbance. Abundance and productivity were lower in 1998 than in previous years, due largely to El Niño effects. Nonetheless, Brandt's Cormorants still produced 1.53 chicks/pair in 1998, higher than the 25-year average for birds in the established, offshore Farallon Island population (1.35 chicks/pair). In 1997 and 1998, we looked at activity budgets and chick-feeding rates on Alcatraz, to begin to investigate this paradoxical high productivity in the face of considerable disturbance, as well as how cormorants' behavioral strategies may vary in El Niño years. Overall monitoring of Brandt's Cormorants on Alcatraz will continue in order to evaluate the long-term stability of the population. Our data, along with additional information on prey dependence, and similar information from other colonies, may help shed light on meta-population changes, especially the coastward movement of this species in central California.

BEHAVIOR OF MARBLED MURRELETS IN RESPONSE TO SURVEY VESSELS DURING AT-SEA SURVEYS: IMPLICATIONS FOR USE OF LINE TRANSECTS

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There is general consensus that Marbled Murrelets can be censused best at sea. In addition, there is growing consensus that line transect sampling is the best at-sea survey method for doing so. This method employs DISTANCE software that calculates corrected bird densities by estimating the percentage of birds that are not detected at various perpendicular distances from the transect line. However, the validity of line transect sampling rests on two assumptions: (1) that all birds are detected on or near the transect line, and (2) that birds do not move significantly away from the transect line prior to being detected. We tested these assumptions on boats of three different size-classes ranging in size from 19 to 44 feet. Few significant differences were detected among boat classes. About 10-15% of murrelets were missed on or near (≤ 40 M) the transect line. In addition, murrelets moved an average of 2-5 M away from the transect line prior to detection. The rate of movement away from the transect line was not related to the distance in front of the boat at which they were detected. In addition, murrelets were detected at an average distance of 59 M in front of survey vessels, but did not fly or dive in response to survey vessels until they were much closer to them; these results suggest that murrelets were detected before being significantly disturbed by survey vessels. The effect of errors of this magnitude on murrelet density estimates calculated by DISTANCE, and their implications for use of line transect methodology to survey for murrelets at sea, will be discussed in a sister paper.

RESULTS OF SEABIRD AVOIDANCE EXPERIMENTS AND OBSERVATIONS OF BYCATCH REPORTED BY FISHERMEN TO IPHC SAMPLERS IN ALASKAN AND CANADIAN PORTS IN 1998

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Regulations implemented in 1997 for groundfish and in 1998 for Pacific halibut to require seabird avoidance devices in Alaskan longline fisheries also required monitoring of the effects of the regulations. The lack of observer coverage on halibut vessels precludes direct observations of seabird bycatch. At the request of the U.S. Fish and Wildlife Service (FWS) and the U.S. National Marine Fisheries Service, the staff of the International Pacific Halibut Commission (IPHC) interviewed Pacific halibut longline fishermen in Alaska (and British Columbia) to collect data concerning bycatch of seabirds and observations of short-tailed albatross. Tori lines and towed buoy bags were the most common avoidance devices, and had reported bird bycatch rates among the lowest of devices used. The reported seabird bycatch rates for the halibut fishery in 1998, after implementation of the avoidance regulations, were about 10-15 percent of the rates reported by FWS for the groundfish fisheries before the avoidance regulations. Either the avoidance regulations worked, the fishermen underreported seabird bycatch, a bird bycatch difference occurs between groundfish and halibut fisheries, or all three. Highest reported seabird

bycatch in May and reported sightings of short-tailed albatross through the summer were consistent with previous reports. However, fishermen in some areas reported no seabird bycatch, a likely indicator of underreporting. The IPHC staff seeks comments on the suitability and desirability of collecting seabird bycatch data with interviews, as long as direct observations from observers are not available.

During a longline survey in the Gulf of Alaska, IPHC staff alternated deployment of a bird bag with no bird bag as a pilot experiment to evaluate methods that might be employed in a larger comparison of effectiveness of bird avoidance devices. Thirteen sets, six with bird bag deployment and seven without, caught no seabirds. Seabirds attacked longline gear about half as often when a seabird avoidance device was used compared to sets without a device. Longline sets made with the bird bag had proportionately more birds flying than sitting in the vicinity of the longline gear.

SEABIRD ABUNDANCES OFF SOUTHWEST WASHINGTON, 1972-1998

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Data acquired during July-October on 226 bird-watching trips off Grays Harbor showed changes in numbers of seasonally-resident birds over time, both long-term and also apparently associated with events like the 1976 'Regime Shift', the ENSO event of 1983-1984, and the prolonged 'event' of the 1990s. Over the period of 27 years, Black-footed Albatrosses and Northern Fulmars, associated with commercial fishing activity, increased, as did Brown Pelicans and Rhinoceros Auklets. Sooty Shearwaters and four regionally-breeding alcids decreased. Seasonally migrant species — phalaropes, *Stercorarids*, Sabine's Gull and Arctic Tern — were variable, in some cases highly variable, interannually.

MAGELLANIC PENGUINS AT PUNTA TOMBO, ARGENTINA: DO TOURISTS PUSH THEM OVER THE EDGE?

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Over 40,000 tourists visit the Magellanic Penguin (*Spheniscus magellanicus*) colony at Punta Tombo, Argentina every year. The tourists walk directly in the colony, often within inches of nesting birds. To determine if this ecotourism causes elevated stress in penguins, we compared the number of agonistic head movements during 15 minutes of human contact and the level of corticosterone in the blood after 15 minutes of contact between tourist-exposed and naive birds. Tourist-exposed birds had significantly fewer agonistic head movements and significantly lower levels of corticosterone than naive birds, suggesting habituation to human contact. Furthermore, in both naive and tourist-exposed birds, levels of corticosterone after 15 minutes of human contact were far lower than that of penguins subjected to an extreme stress event of capture and one-hour of continuous handling. These results indicate that current ecotourism does not subject Magellanic Penguins to extreme stress. We also compared naive birds with one day of human contact to naive birds exposed to 10 consecutive days of human contact and found a significant decrease in the behavioral response and a decreasing trend in the hormonal response in 10-day birds. This result suggests that newly exposed birds may habituate quickly to human contact and

slight increases in ecotourism at Punta Tombo (both in numbers of people or in area of visitation), if well controlled, may not adversely affect nesting Magellanic Penguins. However, continued study of higher levels of human contact (i.e. beyond 15-minutes) are warranted.

CURRENT AND HISTORICAL POPULATION MONITORING: "EASY" MOLECULAR APPROACHES TO COMPLEMENT DIRECT CENSUS AND MONITORING TECHNIQUES, WITH EXAMPLES FROM THE AUKLETS (*CHARADRIIFORMES: ALCIDAE*)

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Population and productivity monitoring are fundamental components of any research program in organismal biology. Knowledge of current and historical population dynamics is essential, particularly when species conservation becomes an important issue. Traditional seabird population monitoring projects provide much information on population trends, and many people are involved in the collection of these data, over numerous seasons. Molecular methods, such as DNA sequencing, SSCP (single stranded conformational polymorphism), and microsatellite analyses can be used to complement existing census and monitoring projects. Molecular methods allow the identification of both current and historical population trends, including effective population size and structure at different depths in the evolutionary history of species. Molecular techniques and their corresponding analyses may be accomplished with relative speed and ease, and may be especially useful in the study of populations for which no data exist, or for which data do not span many generations. Assessment of levels of genetic variation can be used to identify vulnerable populations, and to estimate the degree of gene flow or movement of individuals among populations. Often, molecular results confirm what has been observed through statistical trends of population growth and decline, or been suggested by banding studies. We discuss current and historical population sizes of least and crested auklets (*Aethia pusilla*, and *A. cristatella*) as determined by SSCP and direct sequencing analyses. Effective population sizes appear to have been very large for both species (on the order of hundreds of thousands of individuals) over the past several hundred thousand years, if not longer.

PETREL PUZZLES AND PROBLEMS

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I will discuss a range of difficulties and unknowns — anatomical, behavioural, and physiological — regarding tubenoses, e.g. the roles of olfaction, capture of birds using vocal and other lures, census methods, sound production, birds in deep burrows, and DNA taxonomy.

GENETIC STRUCTURE AMONG COMMON MURRE POPULATIONS FROM BRITISH COLUMBIA TO CALIFORNIA

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The purpose of this study is two-fold: (1) to help evaluate the relative probability of success of several oil spill-related restoration projects (including natural recovery) for Common Murres in Washington; and (2) to understand both the overall geographic structure of murre populations in the eastern Pacific, and the evolution of that structure. To these ends, we extracted DNA from murre blood or tissue obtained from birds near Triangle Island (BC), Cape Flattery (WA), Newport (OR), and Gulf of Farallones (CA). We amplified a variety of genetic markers (loci) using polymerase chain reaction (PCR). These loci encompass three classes of genetic markers, each evolving at different rates: nuclear microsatellites, mitochondrial genes (control region and cytochrome b), and a nuclear intron (enolase). We used both population genetic and phylogenetic techniques to test for (1) differences in genetic distances among murre populations; (2) heterozygote deficiencies (i.e., deviations from Hardy-Weinberg); and (3) phylogeographic structure. Preliminary results suggest that Common Murres are geographically structured from British Columbia to California, with all populations showing significant genic differences for at least one locus. However, analyses on the genetic distances among these populations provided ambiguous results, depending on what loci were included. All populations showed heterozygote deficiencies for at least two alleles, but no population showed deficiencies for all alleles, suggesting that deviations from Hardy-Weinberg may be allele-specific and do not represent significant inbreeding.

PARENTAL MASS ACCUMULATION AND MEAL DELIVERY IN FORAGING ADÉLIE PENGUINS IN AREAS WITH DIFFERENT SEA-ICE CONDITION

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To examine how parents regulate own mass maintenance and meal delivery in relation to the distance to foraging area, diving behavior, parental mass change and meal size were measured in chick rearing Adelie penguins in areas with different sea ice condition. Parents made longer trips (40 - 60 hr) at Davis colony and Dumont d'Urville (DDU) colony (25 - 60 hr) where the sea-ice disappeared in summer than Syowa colony (15 - 25 hr) where the fast sea-ice remained. At each foraging trip, parents accumulated mass faster at Davis (7 g/h) and Syowa 96 (8 g/h) than Syowa 95 (3 g/h) and DDU (-2 g/h). Estimated energy intake per unit time of diving was greater at Syowa 96 (30 KJ/min.) than Syowa 95 (15 KJ/min.), Davis (14 KJ/min.) and DDU (8 KJ/min.). Throughout the chick rearing, average parental mass decrease rate (0.4 - 0.8 g/h) did not differ among colonies but parents brought meals faster at Syowa (2000 KJ/d) than DDU (1800 KJ/d) and Davis (1300 KJ/d). Long foraging trip or greater food intake rate might cause greater mass accumulation but relatively smaller meal delivery possibly because energy accumulation is unlimited while meal size is limited by stomach size. However this trip base variations did not affect parental mass regulation throughout the chick rearing period.

AT-SEA DISTRIBUTION OF XANTUS' MURRELETS IN THE SOUTHERN CALIFORNIA BIGHT, 1995-1997

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In 1995-1997, we captured and radio-marked 153 Xantus' Murrelets at sea beside the largest U.S. breeding colony at Santa Barbara Island (SBI). In 1996-1997, murrelets were patchily distributed in the Southern California Bight (SCB), aggregating in cool upwelling waters mainly near the northern Channel Islands. In 1995, murrelets were less aggregated, mainly in non-upwelling areas during mild El Niño conditions. Average foraging distances from SBI were greater in 1997 (111 ± 44 km) than 1996 (62 ± 25 km). Distances were similar between April and May within years and for "incubating" versus "non-incubating" murrelets. We attributed low numbers of "incubating" murrelets (repeated visitation to SBI) to capture of many "non-incubating" murrelets (pre-, non-, and failed-breeding adults plus non-breeding subadults), rather than adverse effects of radio attachment. Changes in foraging patterns between the 1970s and 1990s were associated with potential changes in prey type and distribution in the SCB. Great flexibility in foraging strategies in the SCB is related to this murrelet's breeding strategy and variable environmental conditions at the south end of the California Current Upwelling System.

RESPONSE OF TUFTED PUFFINS TO INTRODUCED ARCTIC FOX REMOVAL AT NIZKI-ALAIID ISLAND, ALASKA: 1976-1998

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Non-native arctic foxes were introduced to Nizki-Alaid Island in 1911. Foxes prospered by feeding on much of the native avifauna. Burrow nesting species such as tufted puffins were particularly hard hit by foxes. By 1937, those few puffins remaining were restricted to offshore islets inaccessible to foxes. To restore native bird populations, foxes were removed in 1976. Prior to removal, refuge staff counted native birds to document changes after foxes were removed. Since then, staff have visited the island every few years to count. Tufted puffins have responded in the 22 years since fox removal by increasing in abundance and changing their nesting distribution. The approximately 500 individuals observed on the water around the coastline in 1976 had increased to about 3,200 individuals by 1998. Since puffin attendance at the colony is variable, a better indicator of the increase is the number of nesting burrows which increased from about 600 burrows in 1976 to over 12,000 in 1998. Now, nearly all the puffin burrows are on the mainland in areas formerly accessible to foxes. In 1992, 10 index plots of 100m² were established on the mainland and by 1998 the number of burrows in all plots had increased by 60%. In contrast, there are still no nesting puffins on nearby Shemya Island, only 1 mile away, where foxes are still present. The removal of introduced exotic species from island systems as demonstrated at Nizki-Alaid is an effective management action to restore native bird populations.

DIFFERENCES IN TIMING OF INCUBATION SHIFTS BETWEEN MALE AND FEMALE THICK-BILLED MURRES ARE ASSOCIATED WITH VARIATION IN MAXIMUM DIVING DEPTHS

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Data on incubation shifts and maximum diving depths of Thick-billed Murres (*Uria lomvia*) at Coats Island, N.W.T. were collected during the 1998 breeding season. The timing and duration of incubation shifts were observed and measured for a group of known individuals over a series of extended observational periods. Results show an average shift length of 12hrs, with females attending mainly at night and males attending during the day. At the same time, data was collected on the maximum diving depths of several individuals at different times of the day. Preliminary results indicate a difference in average maximum diving depths between those individuals that forage during the day and those that forage overnight, with average daytime diving depths greater than those at night. We suggest that timing of incubation shifts may be associated with changes in Thick-billed Murre foraging behaviour.

BIRD INTERACTIONS WITH SALMON DRIFT GILLNETS IN PRINCE WILLIAM SOUND, ALASKA: 1990 AND 1991

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Marine bird interactions with the Prince William Sound salmon drift gillnet fishery were documented by observers that monitored 9,041 net retrievals in 1990 and 1991. Of 2,291 birds observed approaching nets, 90 (3.9%) became entangled and died (in fewer than 1% of observed sets each year) and 13 were released alive. Marbled murrelets and common murres were the most common birds taken, representing 47 and 22 of the 90 observed mortalities, respectively. Marbled murrelet mortality was documented in both years, with extrapolated take estimates of 1229 and 263 in 1990 and 1991, respectively. Common murres accounted for 22 of 53 bird deaths observed in 1991 (total estimated take of 433); all were observed prior to 22 June. No murre mortality was observed in 1990 but observer effort was initiated on 10 June that year. Characteristics of the fishery, observer effort, and spatial and temporal (annual, seasonal, and diel) patterns of entanglement are discussed.

FIRST YEAR RESTORATION EFFORTS USING SOCIAL ATTRACTION TECHNIQUES RESULT IN COMMON MURRE ATTENDANCE AT A HISTORIC COLONY IN CENTRAL CALIFORNIA

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San Pedro Rock (SPR) was once a colony consisting of at least hundreds of Common Murres before being extirpated by eggging and other anthropogenic disturbances in the early 1900's.

Breeding by murre on SPR has not been recorded since 1908. We began regularly monitoring seabirds at SPR in 1996 from the mainland. Murres were not observed during the 1996 and 1997 breeding seasons. After two years of positive results using social attraction techniques at Devil's Slide Rock (DSR), we expanded similar methods to SPR in 1998. A total of 324 decoys and two independent solar powered sound systems were deployed in April. Seven weeks after deployment one murre was spotted amongst decoys. A high count of 24 birds occurred in June. These sightings represent the first regular attendance by murres recorded in over 90 years. We consider attendance soon after social attraction techniques were implemented a positive step towards the reestablishment of a Common Murre colony on SPR.

DO DIETS OF COMMON MURRES REFLECT THE COMPOSITION OF LOCAL FISH STOCKS?

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We investigated the diets of common murres *Uria aalge* and their chicks from 1995 - 1997 while sampling fish near three seabird colonies from 1996 - 1997 to evaluate whether these birds diets are good indicators of local fish stocks. Murre diets were composed primarily of fish. We found adult diets to vary significantly from trawl catches in all but two cases (Chisik Island in 1996 and the Barren Islands in 1997). Chick diets varied from trawl catches at all three colonies. Trawl catches in the vicinity of the Barren Islands were least diverse and contained mostly gadids such as walleye pollock *Theragra chalcogramma*. Murres from the Barrens Islands ate mostly gadids, but fed their chicks osmerids (capelin *Mallotus villosus*). Trawls at Gull Island contained Pacific sand lance *Ammodytes hexapterus* and gadids. Murres from Gull Island ate almost exclusively sand lance, but a greater proportion of large sand lance than were caught in trawls. Chicks were fed osmerids. Trawls were most diverse in the vicinity of Chisik Island. Murres from Chisik Island ate a variety of prey, but fed their chicks osmerids. The composition of adult murre stomach samples varied more between colonies than between years. We conclude that adult murre diets may reflect the composition of local fish stocks, whereas murre chick diets do not.