

PACIFIC SEABIRD GROUP

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ABSTRACTS OF PRESENTED PAPERS

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PLENARY TALKS

THE DIFFERENCE BETWEEN REAL AND IMAGINARY SEABIRD STUDIES

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People have always been interested in seabirds as a source of first food, feathers and fertilizer, and then information (often falling into similar categories). The Classical Greeks made much progress studying them, until academics put an end to it for 2000 years. Until recently the birds were thought to live in a formless void out at sea which nobody considered their business, until many of our young people (including me at the age of 10) were drafted into the Royal Navy or posted to islands during World War II, and a society was then set up in the Navy (which has a history of support for research since the time of Cook and Darwin) to continue their work, and it has just celebrated its 50th anniversary. When I grew up and became involved in the analysis of its results it appeared too little was being done at the land-sea interface, where many important things happen, so in 1960 I proposed to selected academics that we form a group to promote local work. They saw no profit in it, but five years later the amateurs, who had found that sea-watching often revealed supposedly rare birds, proved enthusiastic.

This anticipated three emerging crises, over pollution, fishing, and conservation of the breeding-places. Unfortunately they have led to much loose thinking by armchair ornithologists about threats to seabirds and possible remedies, resulting in much at best irrelevant and at worst unkind "research" and bad advice. Problems which require more attention include the impact of natural forces such as long and short-term meteorological and oceanic fluctuations and volcanic eruptions, orders of magnitude greater than anything yet achieved by man; the extent to which such factors may cause birds to move around, so that possibly attention is not always being paid to the right problems at the right times and in the right places, or the money raised to combat them spent as effectively as it might be; and indeed often whether the birds are even being identified and counted accurately, and correct and relevant conclusions drawn from the results. There is a need for critical examination of such considerations based on more solid fieldwork, before a new generation decide to make their mark by doing this for us.

PRINCE WILLIAM SOUND SEABIRDS: STABILITY AND CHANGE

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The spill of the oil tanker *Exxon Valdez* in 1989 was a major perturbation for Prince William Sound (PWS), Alaska, but it occurred against a background of other natural and human-caused perturbations that may have masked or accentuated its effects. The *Exxon Valdez* Oil Spill Trustees, freed from the need for litigation-based science, initiated three large projects to achieve an understanding of this background. One of these, the Alaska Predator Ecosystem Experiment (APEX Project), is using an ecosystem approach to determine whether a change in food availability in the Sound has occurred that might be limiting recovery of several seabird and marine mammal species. APEX has eighteen subprojects, looking at everything from fish distribution and diet, through seabird foraging and diet, to reproductive success and population dynamics. The project focuses on the Sound, but also looks at the dense bird populations of the Barren Islands and the more stable populations of Kachemak Bay, in lower Cook Inlet. This is a report on the first two years of the project's five-year lifespan; it is very much a collaborative work in progress.

Initial analysis of pre-existing trawl data for the Gulf of Alaska suggested that major ecosystem shifts occurred before the spill, with lipid-rich pelagic species such as capelin and crustaceans replaced by lipid-poor demersal pollock and by predatory cod. In PWS, Pigeon Guillemots switched from mixed diets of pelagic and inshore fish to primarily inshore species such as gunnells. Marbled Murrelets switched from sand lance to juvenile cod. Populations of fish-eating seabirds and marine mammals decreased, while those eating shellfish and other benthic species remained stable. More recently, there is evidence of a return ecosystem shift to capelin and sand lance.

For seabirds, PWS appears to be quite different from Cook Inlet and the Gulf of Alaska. In PWS, the commonest bird, Marbled Murrelet, is a solitary nester that often feeds alone or in pairs. Common Murres, a large-patch specialist, are rare in the Sound but common as a nester and in foraging flocks in the Barrens and Kachemak Bay. Direct acoustic surveys of fish in the Sound show only small surface patches of fish, with most of the biomass below the reach of surface-feeding seabirds. Forage flock size is correspondingly small. In contrast, both direct acoustics and large feeding aggregations of Hump-backed Whales and seabirds around the Barrens and northeast Kodiak Island demonstrate the presence of kilometer-sized patches of capelin.

In PWS, Black-legged Kittiwakes and Glaucous-winged Gulls are sometimes dependent on deep-diving Marbled Murrelets or Tufted Puffins to bring prey to the surface, where the larids take them directly or through kleptoparasitism. Murrelet and kittiwake flocks tend to occur closer inshore and in shallower water than do the smaller puffin flocks.

Seabird reproductive responses to between-year and between-region variations in prey composition and abundance appear to be complex. Kittiwakes show a narrow choice of foraging habitat but a wide spectrum of foraging ranges and patch densities. Guillemots have limited foraging habitats and range, but select a wide range of prey densities. In contrast, Tufted Puffins use a variety of foraging ranges, but usually forage on low-density prey.

Variations in foraging effort, such as distance traveled, meal size, and number of feedings may buffer reproductive success. Variation in reproductive parameters appear to be linked to lipid levels in diets of kittiwakes, but not of puffins which have young that may make more efficient

use of low-lipid prey. Guillemot breeding numbers appear to reflect the abundance of lipid-rich prey, but reproductive success may itself be insensitive to lipid levels.

AGE AND EXPERIENCE AS FACTORS IN SEABIRD BREEDING SUCCESS: LESSONS FROM THE THICK-BILLED MURRE

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Changes in breeding success with age have been reported for many bird populations and are almost universal among seabirds. The cause of such changes has been variously ascribed to changes in optimal reproductive investment, to changes in foraging skill with increasing age, and to improvements in breeding competence with increased breeding experience. Variation in age at first breeding within seabird populations means that breeders of a given age include individuals with different amounts of prior breeding experience. This allows us to distinguish between the effects of age and experience in determining reproductive success.

At Coats Island, northern Hudson Bay, a study of the reproductive success of Thick-billed Murres in relation to age has been ongoing since 1990. Age at first breeding varied from 3-8 years. Mean reproductive success increased with age up to 10 years. Most of the difference in reproductive success among age classes was established during the incubation period. The success of young birds in rearing chicks, if they managed to hatch them, was not significantly lower than that of older birds, although the chicks of the young birds tended to grow more slowly, presumably because they were fed less. Experienced pairs, comprising birds that had bred for at least three years previously, achieved the maximum mean success of about 0.8 chicks/pair. The success of pairs comprising one experienced and one young bird was closer to that characteristic of the age class of the young bird than that of experienced pairs.

When birds of the same age, but different experience, were compared, female success increased with experience more than male success. When birds of the same experience but different age were compared, age had little effect for females, but had a significant effect for males. Birds mated to experienced breeders did better than those of the same age and experience mated to inexperienced birds. The effect of age on breeding success found for male Thick-billed Murres may relate to the fact that birds starting to breed at an older age generally mate with more experienced partners than those starting young.

The results obtained for Thick-billed Murres do not match those obtained for other seabird species, which tend to reach asymptotic levels of breeding success within two years of starting to breed. The reason for this difference may lie in the importance of site quality for murres and the fact that as birds gain in experience they tend also to attain better quality sites or mates. Overall, it appears that increase in experience is the main factor causing reproductive success in seabirds to increase with age.

In populations where birds tend to return to the same site each year, the new partners of birds that have lost a mate since the previous season are generally birds of limited breeding experience. Consequently, a bird that has lost its mate will usually have lower reproductive success in the first year or two after the loss than it had before. This potentially leads to a direct and non-compensatory effect of adult mortality on reproductive success. Such an effect has implications for the recovery of populations following oil spills, or other catastrophic mortality.

PAPERS

EXPERIMENTAL RELEASES OF OIL-SPILL REHABILITATED COOTS: TESTING THE HYPOTHESIS OF LINGERING EFFECTS

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In spring 1995, 37 oil-rehabilitated coots (RHB) from Southern California were radio-tagged (with mortality detectors), color-marked for individual recognition, wing-clipped (one wing), and “soft-released” into two experimental marshes near Davis, California. 38 matching, non-rehabilitated coots (CON=controls), captured in the Central Valley, were similarly handled, mixed equally, and released. Supplemental food was provided. We studied survival, behavior, and condition, comparing RHB and CON. Behaviors were quantitated daily and the enclosed treatment group sampled monthly (4 periods) to determine health (via blood sampling). As old remiges were replaced, individuals dispersed and were monitored 3 times with aircraft over northern California.

Survival prior to normal dispersal was significantly lower in RHB coots (Chi^2 tests: $P < 0.01$ in enclosure; $P < 0.05$ overall). Overall survival was 49% in RHB and 76% in CON. RHB coots preened more both on land and on water, slept less during the day, and exhibited feeding and drinking behaviors more frequently than CON coots (Mann-Whitney U-tests, $P < 0.05$). Feather wear in RHB coots was greater. RHB coots completed their annual molt about 2 weeks ahead of CON and dispersed sooner, but directions of dispersal were the same. RHB and CON coots began equivalent in weight, RHB lost weight initially in comparison, but recovered after 1-2 months when both groups finished lighter (as expected for post-breeding birds). Health parameters are reported in the next paper.

VARIATION IN LIPID CONTENT OF FORAGE FISHES AND ITS INFLUENCE ON PRODUCTIVITY OF SEABIRDS IN THE EXXON VALDEZ OIL SPILL AREA

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Lipid content of prey is a primary influence on energetics and potentially productivity of piscivorous seabirds. We measured lipid content of forage fishes to determine energy densities, which were used to estimate energy provisioning rates to seabird broods in the Exxon Valdez oil spill area. Lipids ranged from 3% of dry mass in juvenile pollock to 48% in juvenile herring. Herring and sandlance had the highest lipid contents and energy densities, gadids (pollock, cod, tomcod) had the lowest, and nearshore demersal fishes (blennies, sculpins) were intermediate. Energy densities ranged from 2.0 to 10.0 kJ/g fresh mass. Thus if parental provisioning rates are constrained, the lipid content of forage fishes can make as much as a fivefold difference in nestling energy intake rates.

Diets of Black-legged Kittiwake nestlings at three colonies in Prince William Sound were dominated by juvenile herring and sand lance. Higher energy density and larger meal size resulted in higher energy provisioning rates to kittiwake broods at Shoup Bay compared to Eleanor Island. Incidence of brood reduction was lower at Shoup Bay than Eleanor Island, suggesting that productivity of kittiwakes is limited by availability of high-quality forage fishes (i.e., juvenile herring and sand lance).

AT-SEA DENSITY MONITORING OF MARBLED MURRELETS IN CENTRAL CALIFORNIA: METHODOLOGICAL CONSIDERATIONS

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In 1995, we conducted at-sea line transect surveys for Marbled Murrelets to determine density off the coast of central California and to explore the utility of various survey protocols. Surveys were designed to compare line versus strip transect methods, and reveal the effects of distance from shore, viewing conditions and seasonal trends on density estimates. We conducted 12 paired (24 total) at-sea line and strip transect surveys that were 20 km long at 400 m and 800 m from shore on consecutive days. We also performed nine surveys that were 10 km long and at distances of 400 m, 900 m, 1400 m, 2400 m, 3400 m and 4400 m from shore. Density estimates calculated using line transects were significantly greater than estimates based on strip transects of 100 m and 200 m widths. Marbled Murrelet density ranged from 2.4 - 39.4 birds/km² at 400 m from shore and from 0.0 - 16.5 birds/km² at 800 m from shore. Density was higher on the 400 m than on the 800 m survey on 22 of 24 survey days. Densities measured on consecutive days were highly correlated on the 400 m transect but not on the 800 m transect. Line transect densities on the 400 m transect were higher when conducted under better viewing conditions. Statistical power analyses are presented to show the relative power to detect trends in population density using various survey protocols including varying number of survey replicates per year and use of line or strip transects. We suggest that at-sea surveys should focus on detecting trends in density rather than population size.

CASSIN'S AUKLET NESTLING DEVELOPMENT AND DIET: CONTRIBUTIONS OF OCEANOGRAPHIC CONDITIONS TO INTERCOLONY VARIATION

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Knowledge of the marine prey base species composition and productivity are fundamental to interpreting the causes of variation in seabird reproductive success. We compare nestling development of Cassin's Auklet (*Ptychoramphus aleuticus*) at Triangle and Frederick Islands which lie in different oceanographic domains along the British Columbia coast. Growth rates were higher on Frederick Island in 1994, 1995 and 1996. The difference in growth was most extreme in 1996 when nestlings on Triangle Island experienced almost complete fledging failure. We will evaluate the contribution of nestling diet species composition to the observed variation

in growth. We will examine historical records of nestling diet and growth from the same colonies in relation to recent shifts in levels of winter primary production off the west coast of Vancouver Island.

EFFECTS OF HUMAN DISTURBANCE ON BREEDING BIOLOGY OF MAGELLANIC PENGUINS

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The effect of human disturbance on wildlife populations is a growing concern. Increasing exposure of penguins to human activities associated with tourism, make it essential to understand the effects of human disturbance on penguin populations. Magellanic Penguins at Punta Tombo, Argentina are an ideal population for investigating effects of human disturbance because they have been the subject of a long-term intensive scientific study that employs commonly used seabird research methods, and they are also an increasingly popular tourist attraction. Using data from six breeding seasons at Punta Tombo, we examined the effects of both research and tourism-related disturbance on various aspects of penguin breeding biology, including egg hatching, chick growth, chick survival, fledging success, site fidelity, and mate fidelity. We found that our research program appeared to negatively affect several breeding parameters of birds in study areas. Most of these effects were not due to obvious injuries to chicks and eggs caused by researchers, but were related to more subtle effects of nest visitation. Intensity of research activity (e.g. frequency of nest visits by researchers) and type of research activity to which the penguins were subjected (i.e. whether birds were handled or merely observed) also affected disturbance. The results of this study indicate that effects of human disturbance on penguins are subtle but significant.

MARBLED MURRELET CRITICAL HABITAT: THE VALUES AND LIMITATIONS

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The U.S. Fish and Wildlife Service (FWS) designated approximately 3.9 million acres of forest land as critical habitat for the Marbled Murrelet on May 24, 1996, including 3 million acres of Federal lands in Late-Successional Reserves. No marine areas were included. Critical habitat is defined as areas containing the features essential to conservation of the species which require special management consideration or protection. Federal agencies are required to ensure that all their actions in critical habitat are not likely to appreciably diminish the value of critical habitat for the survival and recovery of the species, but does not create a management plan or prescribe specific management actions. Wilderness areas, National Parks, and National Wildlife Refuges were not included because they are already protected by law. Marine areas were not included because of the existing laws aimed at reducing or eliminating marine threats. Critical habitat focused on nesting habitat and includes any area within the boundaries that contains individual potential nest trees, or is ½ site-potential-tree height and within 0.5 mile of a potential nest tree. Critical habitat is one of several tools for recovering species but will not achieve recovery on it's own.

REPRODUCTIVE SUCCESS OF WESTERN GULLS ON ALCATRAZ ISLAND

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In this study I document reproductive success of known-experienced Western Gulls breeding on Alcatraz Island during the 1994-1996 breeding seasons to provide information on the ultimate effect of breeding experience on nest microhabitat, parental investment patterns of chick-rearing and defense, and the interaction between sex, experience and body condition of breeding adults. Alcatraz supports the second largest breeding colony of Western Gulls in northern California, yet it is visited by more than 4,000 visitors daily that may influence breeding success. Information from a long-term banding program was used as background data for this colony, and reproductive success data were collected for the Cistern subcolony from 1994 to 1996. In general, clutch size and fledging success remained stable across years, although the gull population significantly increased. Impacts of tourism were minimized by closure of many areas of the island during the breeding season; however, a special event staged on the island during the 1996 season occurred during peak hatching, and caused significant behavioral and reproductive success impacts to the gull population. The information from this study will be used to provide a long-term management plan for this species, and will assist park managers to balance the natural history and visitor use goals of the island.

RADAR CENSUS OF MARBLED MURRELETS AT 14 WATERSHEDS IN CLAYOQUOT SOUND, VANCOUVER ISLAND

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We used two high-frequency marine surveillance radar units to count Marbled Murrelets entering the mouths of 14 watersheds in Clayoquot Sound, British Columbia, at dawn and dusk in 1996. Radar detections of birds entering the watersheds were higher than those recorded circling or leaving. Maximum counts at all stations totaled 4071 incoming birds at dawn and 1016 at dusk. Numbers of murrelets entering watersheds were compared with a range of landscape parameters, including area and length of watersheds, topography, area of valley-bottom old-growth forest, proportion of watershed affected by clearcut logging and roads, and light distance from oceanic foraging sites. In general the radar counts followed seasonal trends seen in audio-visual surveys (Pacific Seabird Group protocol) at inland stations in the watersheds. Counts of murrelets entering the Bedwell-Ursus watershed (the only one sampled previously) were about half of those recorded in 1995, which conformed with the decline reported in audio-visual detections. We review the value and limitations of radar as a census tool for landscape-level habitat assessment and long-term population monitoring of murrelets.

DISTRIBUTION OF XANTUS' MURRELET NESTING AREAS IN THE CALIFORNIA CHANNEL ISLANDS, BASED ON NOCTURNAL VOCAL DETECTION SURVEYS IN 1994-1996

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Past survey efforts in 1975-1977 and 1991 indicated that almost all Xantus' Murrelets (*Synthliboramphus hypoleucus scrippsi*) in the California Channel Islands nested at Santa Barbara Island, California, and Islas Los Coronados, Mexico. In 1994-1996, we conducted nocturnal vocal detection surveys at coastal stations around all 9 islands to better assess the relative importance of all potential nesting areas. Highest detections/station occurred at Santa Barbara and Los Coronados islands. At Anacapa Island (where near extirpation was suspected from rat predation), we found nests in sea caves and high detections/station, indicating a relatively large population. High or medium detections/station occurred at Santa Cruz and San Miguel islands, including known and newly-discovered nesting areas. Medium or low detections/station occurred at San Clemente and Santa Catalina islands, indicating newly-discovered nesting areas where only single nests had been found before. Newly-discovered nesting areas occurred in steep slopes, cliffs and sea caves (habitats not surveyed previously). No detections were noted at San Nicolas and Santa Rosa islands where little potential habitat existed.

GUT PASSAGE TIME AND ENERGY ASSIMILATION EFFICIENCY IN CASPIAN TERN AND ELEGANT TERN CHICKS: DOES DIGESTION LIMIT FEEDING AND GROWTH?

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Gut passage time and energy assimilation efficiencies were compared for chicks of Caspian Terns and Elegant Terns nesting at the Bolsa Chica Ecological Reserve in southern California. We explored the possibility that the rate at which the chicks are fed by their parents is driven by the rate at which the chicks can process food and the efficiency with which they assimilate energy from this food. Based on observations of the frequencies with which adult pairs of Caspian Terns feed their 2-3 young and adult Elegant Terns feed their single young, we tested the hypothesis that Elegant Tern chicks have faster gut passage times but less efficient energy assimilation than Caspian Tern chicks. We fed a northern anchovy diet to 2-3 week old Caspian Tern and Elegant Tern chicks held individually in cages in a controlled environment room over a 19-33 day period. Carmine dye fed in gelatin capsules with the food appeared in the feces of Elegant Tern chicks significantly sooner (147 min) than that in Caspian Tern chicks (349 min). Acquisition and analysis of data on assimilation efficiencies, growth rates and maintenance rations of the captive chicks are in progress.

NOCTURNAL FORAGING BY WESTERN GREBES: IS THERE A BIOLUMINATING MECHANISM?

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Western Grebes (*Aechmophorus occidentalis*) winter in the coastal marine waters of western North America. Grebes disperse from large roosting flocks at dusk and begin foraging after sunset. Observations during the night, using a night vision scope, confirm that grebes are solitary nocturnal foragers. Western Grebes feed on pelagic schooling fish, primarily herring (*Clupea harengus*). Current theories on why birds may forage in low light conditions suggest that the vertical migration of prey may offer energetic savings by reducing travel time during the dive.

These explanations do not adequately address the problem of finding and capturing prey in near darkness. Daytime foraging birds, specializing on pelagic schooling fish, conduct feeding dives in a series of bouts. Most dives are “search dives” where the bird does not encounter fish. It is likely that as much as 80% of dives are search dives and can be considered an energetic cost of foraging. Although grebes will benefit from the vertical migration of prey, they may benefit more by not conducting “search” dives at night. I propose that bioluminescent trails of fleeing fish are the visual signal for night foraging Western Grebes which search for prey on the surface and do not dive until prey is sighted nearby.

COMPARATIVE CHICK PROVISIONING IN CASPIAN TERNS AND ELEGANT TERNS AT THE BOLSA CHICA ECOLOGICAL RESERVE IN SOUTHERN CALIFORNIA

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Feeding frequency, prey type and prey size were recorded for Caspian Tern and Elegant Tern chicks as they were provisioned by their parents at the Bolsa Chica Ecological Reserve in coastal Orange County, California, to test the hypothesis that Elegant Terns, because of smaller body and clutch size and greater sociality, feed their chicks more frequently than Caspian Terns, whereas Caspian Tern chicks are fed greater biomass per day. Two groups each of Caspian Tern and Elegant Tern chicks were held in enclosures and observed for approximately 100 hours from a pair of blinds on the breeding island. We found that Caspian chicks were fed larger fish than Elegant chicks, whereas Elegant chicks were fed more individual fish per day than Caspian chicks. Results still being analyzed will provide estimated caloric intake per day for chicks of both species. With ongoing shifts in prey abundances and the suggestion that terns may be especially sensitive to fluctuations in food availability, information from this study will help predict the likelihood of foraging and reproductive success of these two species at Bolsa Chica and elsewhere.

USE OF RADAR AS AN INVENTORY AND MONITORING TOOL FOR MARBLED MURRELETS IN WASHINGTON AND OREGON

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Concurrent radar and audio-visual observations of Marbled Murrelets were made in 4 drainages in the Olympic Peninsula and in 13 drainages along the Oregon Coast. Radar data suggest that the audio-visual technique is not suitable for estimating numbers of murrelets flying up and down drainages: 50 times more birds were detected on radar than audio-visually. Further, it appears that murrelets in Olympic Peninsula drainages were flying into nesting stands in substantial numbers before standard protocol surveys began: a consistent peak in inland-bound movements occurred approximately 40-80 minutes before sunrise, followed by a seaward exodus that ended approximately 1 hour after sunrise. In Oregon, however preliminary data indicate that inland-bound movements occurred later than at the Olympic Peninsula. Radar counts of murrelets increased steadily during the summer, with mean counts nearly tripling between May and July. Within a month, day-to-day variation in radar counts was relatively low (CV = 14-29%). Results

of these pilot studies suggest that radar is a valuable tool for obtaining indices of abundance for Marbled Murrelets on a watershed scale and also shows great promise as a long-term monitoring tool for murrelets.

VARIABLE TIME BUDGETS OF RHINOCEROS AUKLETS AT SEA OFF SOUTHWESTERN VANCOUVER ISLAND

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Time budgets of adult auklets were measured through visual scans during the 1996 breeding season, near Seabird Rocks. Objectives were to describe adult activities at sea during three breeding phases (incubation, chick rearing and post-fledging) and diurnally, as part of a project examining provisioning efforts in response to variations in prey density and distribution. The time spent foraging remained relatively constant through each phase but the degree of flocking varied. During chick rearing, adults dove a higher percentage of the time in mixed species feeding flocks. Increased flock foraging also coincided with the seasonal appearance of juvenile Pacific Herring in the study area. Thus the appearance of herring and/or the onset of chick rearing seemed to cause this increase in feeding flock use. The time spent foraging also increased from dawn to dusk during chick rearing, apparently due to increased diving to collect chick meals in the evening. Adults rarely foraged in flocks near dusk and adults carrying fish, potentially rearing chicks, were only seen to dive solitarily. Fish species and size collected at feeding flocks also differed from those collected in chick meals at the colony. This dichotomy suggests that adults selected different prey items when central-place foraging than when self-feeding.

SYNOPSIS OF *CEPPHUS* SYMPOSIUM AND DIRECTIONS FOR FUTURE RESEARCH

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The utility of guillemots as indicators depends on the variable that is being monitored and the availability of alternative methods of monitoring. Many factors that affect guillemot reproduction are best measured through direct means. While guillemots may at times provide the first evidence of a change in the nearshore environment, they typically will be most useful as evidence of biotic response to known change.

Several factors lessen the utility of guillemots as secondary indicators, and severely restrict them as primary indicators. Their ability to utilize a wide variety of fishes and invertebrates could render measures of breeding success insensitive to changes in the taxonomic composition (but not abundance) of nearshore prey. Colonies separated by as little as a few kilometers may have markedly different prey bases and associated reproductive traits. Sample sizes of accessible nests can be low, and may be further reduced by predation. Increasing population size and sample size of accessible nests by providing artificial nest sites works in some but not all cases. Physiological responses of nestlings to known doses of contaminants need to be measured in controlled, captive environments.

More effort should be expended to examine those aspects of guillemot biology best suited to monitor change in nearshore ecosystems, followed by development of baseline data in

representative locations and habitats. By carefully selecting breeding populations to serve as indicators, valuable information can be obtained on the local status and trends of coastal habitats.

BLACK GUILLEMOTS AS INDICATORS OF REGIONAL CLIMATE CHANGE IN ARCTIC ALASKA

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Models of global climate predict that polar regions will be among the first affected by temperature increases associated with greenhouse gases. Warming trends have already been recorded in parts of the arctic, including northern Alaska. Studies of Black Guillemot breeding biology near Point Barrow, Alaska have revealed a substantial advancement of the breeding season over the last two decades. The median date of clutch initiation has advanced significantly (4.6 days per decade) from early July in the 1970's to late June in the 1990's. Both date of median clutch initiation and the date the first egg was laid in the colony were correlated with annual measures of snowmelt. Snow accumulation in and around the ground-level manmade nest sites prevent access to nesting cavities and the initiation of breeding. Meteorological records from Barrow indicate that date of spring snowmelt has been advancing for almost 50 years. The late snowmelt in the late 1940's and 1950's would have regularly delayed clutch initiation until mid-July, increasing the chances of chicks being trapped in nest sites by September snow storms. Black Guillemots require 65 days from egg laying to chick fledging and snowdrifts frequently form by the middle of September. The snow-free temporal window wide enough for successful breeding likely has occurred only in recent decades.

CONSERVATION OF SEABIRDS: A DIFFICULT EDUCATIONAL TASK

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Unlike 100 years ago when protecting a seabird colony from human exploitation or other introduced predators was enough, today the effects may be direct (e.g., harvesting for consumption) or indirect (e.g., competition with fishing operations for food, incidental mortality in fishing nets, reproductive failure due to synthetic hormone mimics). The categories of threats to seabirds have changed over the last century. However, the most important changes are in the cumulative intensity and extent of the threats which have increased manifold resulting in measurable, region wide shifts in the composition and distribution of marine species. Furthermore, unlike historical disturbances which affected only reproductive individuals and their eggs confined to breeding colonies, current disturbances have the potential to affect all age-classes of seabirds, year-round, in all parts of the ocean. Despite growing emotional ties to seabirds other larger factors continue to exert negative pressures. Rising human populations increase the demand for fish protein. The structure of the global economy significantly devalues the price of fish (a commodity) relative to the price of marketing fish (a service) because commodity prices have been allowed to ignore the costs imposed on linked species and systems. Legislation currently exists to protect many threatened seabirds, but until education increases awareness of the environmental costs of existing human institutions, legislation is not sufficient.

CONSERVATION PROBLEMS AND OPPORTUNITIES IN THE LINE ISLANDS, CENTRAL PACIFIC OCEAN

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The Line islands extend from Palmyra Atoll, south of Hawaii and under United States jurisdiction, through the central Kiribati Republic Line Islands of Kiritimati (Christmas), Tabuaeran (Fanning), and Teraina (Washington). South of these populated islands are the dry and uninhabited central Pacific Line Islands of Malden and Starbuck, and the more southerly trio of the wetter atolls of Vostok, Flint, and Caroline, also controlled by the Republic of Kiribati. Most of the islands were mined for guano in the 19th and early 20th centuries, suggesting a long history of use by breeding seabirds. Christmas Island may be the world's largest tropical seabird colony, and is under severe pressure from and ever-increasing human population and resulting impacts. I visited most of these islands in September 1995, and found that feral cats and rats still occur on most if not all the islands. Although Christmas Island is worthy of any and all intense international conservation efforts, significant results may be more easily achieved by eradication of non-native predators from Malden, Starbuck, Vostok, Flint, and Caroline atolls. Palmyra contains one of the most important stands of native *Pisonia* forest under United States jurisdiction, and should be closely monitored to preserve this unique resource.

SEASONAL AND SEX-BASED VARIATION IN THE ADRENOCORTICAL RESPONSE TO CAPTURE STRESS IN MAGELLANIC PENGUINS

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Secretion of adrenal corticosteroid hormones is a typical part of the response of most vertebrates to stressors, including capture and handling. However, the magnitude of the response varies considerably among species, and some species modulate the response at different times of year. In particular, species with tightly constrained breeding seasons, and those that breed in stressful environments (e.g., deserts) may significantly down-regulate their hormonal response to stressors. Magellanic Penguins are constrained as to timing of breeding, breed in the desert, and in addition, fast for up to 3½ weeks during incubation. I studied the response of breeding penguins to capture and handling across the course of the breeding season, and predicted that they would down-regulate corticosterone secretion during the prelaying and incubation periods. Animals were captured at their breeding colony at Punta Tombo, Chubut, Argentina, and held for 35 minutes, while a series of blood samples was collected for assay of corticosterone levels. Both sexes down-regulated the stress response during different breeding stages, but in an alternating fashion, and not as predicted. Strength of the response was most closely related to the body weight (i.e., condition) of the animal, with fat animals responding less than lean ones.

PATTERNS OF PARENTAL CARE BY MALE AND FEMALE CRESTED AUKLETS AT BULDIR ISLAND, ALASKA

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Observers have noted enigmatic patterns of male and female chick provisioning by Crested Auklets (*Aethia cristatella*), which are monogamous sexually monomorphic seabirds with bi-parental care. In July 1996 we used radio telemetry to quantify attendance of both members of seven breeding pairs at a large auklet colony. Parents were captured within a few days after their chick hatched and were fitted with 1.6 g radio transmitters (0.6% of adult body mass) attached to

a leg band. The birds' presence near their chicks was recorded by a scanning radio receiver linked to whip antennas in each crevice, and the data was logged automatically every 3-4 minutes for at least 30 days. Diurnal brooding by males and females decreased from virtually continuous during the first four days after hatching to zero at day seven. Feeding visits occurred primarily during the two main activity periods (1000-1400h and 2200-2400h), although visits to the crevice occurred throughout the day and night. Chicks received about four feeds per day throughout their development. Male and female attendance patterns will be described. Chick growth at crevices with radio-equipped parents did not differ significantly from crevices with parents without radios.

BLACK NODDY BEHAVIOR IN THE POST-FLEDGING PERIOD

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Post-fledging parental care of several months duration has been reported in many seabird species; however, the roles of the parents and offspring in maintaining this care are not often known. I observed parent-offspring interactions and patterns of attendance on the nest throughout the post-fledging feeding period (of up to four months) in color-banded Black Noddies on Tern Island and Laysan Island in the Northwestern Hawaiian Islands (NWHI), and on Heron Island in Australia. Individual variation among fledglings in begging intensity and persistence, sexual differences between parents in contribution to parental care, and differences among populations in the duration of the post-fledging feeding periods were examined. Black Noddies in the NWHI are resident year-round, have a protracted nesting season, and have high mate and nest-site fidelity. Also, about 40% of pairs on Tern Island double-brooded (fledged two successive broods within a nesting season). To preserve nest ownership for subsequent nesting, a pair must maintain its presence on the nest. Fledglings may take advantage of their parents' continued presence on the nest by continuing their begging behavior. Evidence suggests that some parents may move to a new nest site to evade a persistently begging fledgling; however, fledglings also appear to be important in defending the nest from take-over.

POSTNATAL ENERGETICS AND THE ONTOGENY OF THERMOREGULATION FOR FOUR SPECIES OF ANTARCTIC FULMARINE PETREL

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We measured standard metabolic rate (SMR) of chicks and adults of four species of Antarctic fulmarine petrel: Snow Petrel (*Pagodroma nivea*), Cape Petrel (*Daption capense*), Antarctic Petrel (*Thalassoica antarctica*), and Southern Fulmar (*Fulmarus glacialisoides*). Body temperature (T_b) of chicks increased sigmoidally with mass from hatching to 8-12 days of age; T_b peaked at 38.6 to 39.0°C. Young chicks were homeothermic: during metabolic studies, T_b of 3 and 8 day old chicks did not vary with air temperature (range 0 - 30°C; $P = 0.94$). Lower critical temperature of chicks decreased from 15-22°C at 3 days of age to -4 to 8°C for 28 day old chicks, while that of adult birds was intermediate at 5-13°C. Mean SMR at thermoneutral for each of the four species was higher than predicted for nonpasserine birds, but similar to that predicted by Ellis (1984) for Charadriiformes breeding at similar latitudes. Resting metabolic rate accounted for 71-109% of the estimated total metabolic energy required to fledging for birds of this mass.

The implications of these findings for life in the Antarctic will be discussed. (Supported by Australian Antarctic Division project No. 7020 and NSF grant OPP 92-18536).

A TRANSECT METHOD TO QUANTIFY MARBLED MURRELET HABITAT QUALITY AND DESIGN LANDSCAPE CONSERVATION STRATEGIES

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Most studies examining Marbled Murrelet habitat use have measured forest characteristics using fixed or variable radius plots. However, such methods may have limited utility when small patches of suitable habitat exist in larger forested sites or scattered remnant trees are present. We developed a transect method that consists of a 10% or 100% cruise where observers traversed every acre of the stand to be sampled. Using this method, we sampled 21 occupied and 21 unoccupied stands representing 3,328 acres of potential marbled murrelet habitat on the Elliott State Forest in the Oregon Coast Range. We found the transect method adequately sampled heterogeneous habitats. Using this habitat data, a logistic regression model was developed that predicted stand occupancy with an overall accuracy rate of 76%. Since data was collected and collated for every acre sampled, detailed habitat maps showing the probability of occupancy of each acre could then be created for any area. These habitat maps accurately displayed information on the location, dispersion, and quality of the habitat sampled. This information can be used to develop long-term conservation and management strategies. Mapping habitat at larger scales would allow a landscape approach to the management and assessment of marbled murrelet habitat. This approach would be a powerful tool to help protect and conserve marbled murrelet nesting habitat over time.

FULMAR COLORS AND KITTIWAKE CLUTCHES: SHAMELESS SPECULATIONS REGARDING LONG-TERM CHANGE

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A hundred years ago, Red-legged Kittiwakes apparently were more widely distributed and numerous than they are today. On the Pribilof Islands, Elliott (1882) reported that Red-legs usually laid two eggs per clutch, and sometimes three. Today, multiple-egg clutches are so rare in this species that they are generally regarded as aberrations or of doubtful origin. Early accounts also suggest marked shifts in the proportions of different color phases of Northern Fulmars on the Pribilofs and on Chagulak Island in the eastern Aleutians. What could account for such rapid shifts in fundamental demographic traits of organisms having generation times of 20-30 years? Kittiwakes and fulmars form a small foraging guild comprised of offshore surface feeders on fish and macrozooplankton. Overlap in the breeding distribution of fulmars and Red-legged Kittiwakes in the Bering Sea suggests close ecological affinities between these two species in particular. Both species forage heavily at night, although I suggest that dark-phase fulmars are better adapted for this than light-phase birds. I further suggest that an ocean regime shift occurred in the early 1900's favoring daytime foragers over nighttime foragers at the Pribilof Islands and nighttime foragers over daytime foragers at Chagulak. In response, night-feeding Red-legged Kittiwakes reduced their clutches to one egg, whereas fulmars changed body color to the most appropriate plumage in each environment. Among other radical features, this hypothesis requires that fulmar phenotypes can change over the life of an individual.

DECLINE OF PIGEON GUILLEMOT POPULATIONS IN PRINCE WILLIAM SOUND, ALASKA, CHANGES IN CHICK DIET, AND INCREASED NEST PREDATION

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Pigeon Guillemots are cavity-nesting, pursuit-diving seabirds that forage in the nearshore environment on both demersal and schooling fish. Since the late 1970s and early 1980s there has been a dramatic change in the diet of Pigeon Guillemot chicks on Naked Island in Prince William Sound, Alaska. In the years 1979-1981 Pacific sand lance (*Ammodytes hexapterus*) were the single largest component (42%) of the diet, while in the five years 1989-1990 and 1994-1996, sand lance accounted for a much smaller fraction (13%) of the diet. The increase in the proportion of gadids has been equally dramatic, from 4% to 21% for these same periods. Demersal fish such as gunnels (Pholidae), pricklebacks (Stichaeidae), and sculpins (Cottidae) have always been an important component of the diet although their relative contribution has increased. Other schooling fish in the chick diet include herring and capelin, but their relative contributions have varied widely from year to year. The overall population of guillemots at Naked Island has decreased from over 2000 in the late 1970s to about 1200 in the 1990s. The decline in the guillemot population could be related to this apparent change in prey abundance, which may be a manifestation of a major shift in the marine ecosystem. Greatly increased rates of predation at the nest may also be affecting the numbers of guillemots, at least on Naked Island.

PIGEON GUILLEMOTS AS INDICATORS OF THE NEAR-SHORE ECOSYSTEM OF AN OFF-SHORE COLONY

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Pigeon Guillemots (*Cephus columba*) on Southeast Farallon Island, California, forage relatively close to the shores of the Farallones than other breeding seabird species on the island. This near-Farallones ecosystem includes coastal, slope and shelf habitats and creates a foraging area influenced by numerous oceanographic processes. Pigeon Guillemots exhibit intermediate responses to environmental variability which make it an ideal indicator species. We investigated relationships between oceanographic conditions (prey availability, SST, upwelling intensity) and breeding ecology (productivity, chick growth, chick diet). Reproductive parameters and chick diet showed marked annual variability and several long-term trends were identified. A general decrease in the use of juvenile rockfish and an increase in the use of cottids (sculpins) was observed, but reproductive success has remained relatively constant over the 25-year period.

FORAGING ECOLOGY OF ANTARCTIC FULMARINE PETRELS

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Diets of Snow, Cape, and Antarctic petrels and Antarctic Fulmars breeding on Hop Island, Prydz Bay, Antarctica were determined from stomach contents of adults returning to feed chicks in 1994-96. Diet composition was determined by quantitative analysis (weight, frequency of occurrence, and number of individuals) of stomach contents collected using the water offloading technique. Fish (mainly *Pleuragramma antarcticum*) occurred in 100% of samples from all four species. Krill, primarily *Euphausia superba*, occurred in 97.5%, 85%, 93.3%, and 62.5% of

Snow, Cape, and Antarctic petrel and Antarctic Fulmar stomach samples, respectively. Few samples contained amphipods or squid. By weight, fish comprised 89.5%, 30.8%, 58.2%, and 64.4%, and krill 10.1%, 68.6%, 41.5%, and 35.7% of Snow Petrel, Cape Petrel, Antarctic Petrel and Antarctic Fulmar diets, respectively. Meal delivery rates (feeds/day) during peak chick growth were 0.41, 0.54, 1.03, and 1.33 for Antarctic Petrels, Snow Petrels, Antarctic Fulmars, and Cape Petrels, respectively. Diet composition and provisioning rates suggest that foraging ecologies of Snow and Antarctic petrels are similar, as are those of Cape Petrels and Antarctic Fulmars. Inter-annual comparisons of meal size, diet, and foraging trip length will be discussed. These data, when combined with energetics information, will better elucidate the ecological role of these petrels in the marine ecosystem.

SEASONAL FORAGING ADJUSTMENTS IN PENGUIN PARENTS: QUALITY VS. QUANTITY

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In penguins, individuals' foraging decisions are restricted by the behavior of their mates: prior to leaving chicks unattended (i.e., creche phase), parents can go to sea only after being relieved at the nest. This temporal constraint often necessitates feeding at night when darkness may constrain visual hunting. We predicted that Chinstrap Penguin parents would respond to rising chick demands by: 1) avoiding nocturnal foraging once parents can forage independently, and 2) augmenting time at sea by increasing foraging frequency and/or duration. Radio telemetry revealed that diurnal and overnight trips were common during chick-brooding but overnight foraging declined rapidly following creche. Birds completed two diurnal trips per day more frequently after creche. Chick age and diurnal trip duration were positively correlated, but only after creche. Daily averages of diurnal trip durations fluctuated widely; opposite trends in two years indicated diurnal foraging is also strongly influenced by environmental factors. The onset of creche therefore marks a significant change in penguin feeding behavior: before, trip durations reflect largely less predictable environmental factors, whereas after -- with rising food requirements -- birds apparently enhance the quantity (frequency and duration) and quality (timing) of foraging.

WILDLIFE AGENCY SPONSORED OILED WILDLIFE CARE: A PARADIGM SHIFT

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Although state wildlife agencies are the trustees for all wildlife resources, few provide care for wildlife compromised by oil spills. In 1990, California legislation established OSPR within the California DFG. This was accomplished by placing a \$.04/barrel fee on oil transported or processed in the state for various activities, including the care of oil-affected wildlife. This legislation calls for the establishment of rescue and rehabilitation station(s) and delivery of the "best achievable treatment" for oiled wildlife. Subsequent legislation (two actions) allowed OSPR about \$9 million interest from an Emergency Response Fund over a 4-year period, to establish an Oiled Wildlife Care Network (OWCN) for California. Care centers are being

developed in conjunction with two universities, a marine park, and two wildlife rehabilitation/education programs. Each has varied sources of financial, political and personnel (volunteer) support, assuring that all centers will function in additional useful roles when not in use for oil spill response. The long-term functioning of OWCN, along with a competitive grants program for technology development and research, will be accomplished through the Wildlife Health Center at U.C. Davis. Current research projects aim to improve care and improve both short-term and long-term damage assessments. The OWCN is the first nonprofit partnership of its kind; it allows industry to efficiently meet some of its legal requirements and it obligates the public trustee agency to manage the entire process. OWCN also demonstrates a commitment to integrate wildlife care with resource management and research--it has broad public support.

DISTRIBUTION AND ABUNDANCE OF KITTLITZ'S MURRELETS IN SOUTHCENTRAL AND SOUTHEASTERN ALASKA

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The Kittlitz's Murrelet (*Brachyramphus brevirostris*) is a rare seabird that predominantly ranges within Alaska. Little data is available on its distribution and abundance. We conducted surveys to determine marine bird populations of three areas within the Kittlitz's Murrelet range: Lower Cook Inlet, Prince William Sound, and Southeastern Alaska. In summer, Kittlitz's Murrelets were primarily associated tidewater glaciers or recently deglaciated regions in Prince William Sound and Southeastern Alaska. In Prince William Sound, they also occurred in low densities away from glaciers. In Lower Cook Inlet, where there are no tidewater glaciers, Kittlitz's Murrelets were found in low densities throughout the area. Kittlitz's Murrelets were not observed during the winter in eastern Lower Cook Inlet. They occurred in Prince William Sound in the winter; however, their densities were lower than summer, and they had dispersed away from the glaciers. We calculated abundance estimates \pm 95% CI as: 3,353 \pm 1,718 in Lower Cook Inlet summer; 3,368 \pm 4,073 in Prince William Sound summer; 513 \pm 831 in Prince William Sound winter; and 5,408 \pm 7,039 in Southeastern Alaska summer. The combined estimate for the three areas during summer was 12,130 \pm 8,312. We compare distribution and abundance with historical observations.

GEOGRAPHIC PATTERNS OF GENETIC DISTINCTNESS IN THE GUILLEMOTS

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Divergent populations are often the result of natural selection and/or genetic drift in ecologically marginal areas, and are thought to be major sites of speciation events. We surveyed neutral variation in the mitochondrial control region to reconstruct the global phylogeny of the seabird genus *Cephus*, and to survey population-level variation. Major lineage splitting seems concordant with glacial events in the Pleistocene epoch, while more recent divergence reflects population genetic processes. Spectacled and Pigeon guillemots are sister taxa, while Black Guillemots are most divergent. Subspecies of Black Guillemots vary in levels of genetic diversity, whereas subspecies of Pigeon Guillemots are genetically uniform, reflecting unique evolutionary histories of the subspecies. Our analysis identifies centres of genetic diversity and regions of genetic monomorphism, important both for understanding theoretical evolutionary genetics and for conservation planning.

REINTRODUCTION OF ATLANTIC PUFFINS AT FORMER BREEDING SITES IN THE GULF OF MAINE

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To re-establish colonies of Atlantic Puffin to two historic nesting sites in the Gulf of Maine, northwest Atlantic, 1,904 puffin chicks were translocated from Great Island, Newfoundland to Eastern Egg Rock (EER) and Seal Island National Wildlife Refuge (SI) in Maine from 1973-1989. By 1989, 149 of 914 chicks fledged at EER were resighted at least once in the Gulf of Maine, 42 of which bred at EER. Five pairs nested at EER in 1981, and 15-19 pairs have nested each year from 1985 to 1996 without subsequent translocations. Of 912 fledglings released at SI, 155 were resighted at least once in the Gulf of Maine. Seven pairs recolonized SI in 1992 and the colony increased to 40 pairs by 1996. Decoys helped to attract puffins to both sites. The study shows that nestling Atlantic Puffins can be successfully translocated and that new, productive colonies can result. These benefits must be weighed against variable and sometimes low survival of chicks, labor-intensive and expensive technique and costs to the 'donor' puffin population at Great Island.

PREDATION ON FISH BY CORMORANTS AND PELICANS IN A COLDWATER RIVER

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As populations of some fish-eating birds have increased, their predation on stocked fish has caused growing controversy. We studied the diets and total consumption of Double-crested Cormorants and American White Pelicans before and after fingerling trout were stocked in the North Platte River, Wyoming. For cormorants, suckers (*Catostomus* sp.) were the major prey before trout stocking (85% fresh mass of the diet); but trout consumed increased from an average 12% mass in sampling periods before stocking to 82% mass in samples after stocking. Pelicans ate mainly suckers (84% mass) throughout the study period; trout were only 0.1% of the pelican diet before stocking, and an average 14% after stocking. A bioenergetics model estimated that pelicans and mainly cormorants consumed up to 80% of the mass of trout stocked in 1994. Peak consumption corresponded to maximum demand by cormorant chicks, which overlapped the typical dates of trout stocking. In August 1993, cormorants ate mostly trout (98% mass), indicating that many stocked trout survived through late summer. However, the much smaller fraction of trout in the cormorant diet in spring before stocking (13% mass) than after stocking (82%) suggested that stocked trout declined substantially during winter. Because overwinter survival might have limited trout recruitment between years, it is unclear whether bird predation was additive or compensatory.

NESTS AND NESTING BEHAVIOUR OF MARBLED MURRELETS IN DESOLATION SOUND, BRITISH COLUMBIA

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Twenty-three nest trees of Marbled Murrelets were found in the Bunster Range (n=21) and the Brittain River watershed (n=2) on the Sunshine Coast of British Columbia in 1996. Nests were located using dawn surveys and tree climbing. The 23 trees were in late successional stands (>700 m in elevation) and contained a total of 30 nests: 5 nest trees each contained 2 nests and one tree had 3 nests. All nests were in trees > 62 cm in diameter and > 20 m in height. Nest tree species included Yellow Cedar (n=21), Western Hemlock (n=1) and Douglas Fir (n=1). Data were collected on nest site, tree and stand characteristics and will be analyzed to determine habitat selectivity. Observations of nesting behaviour include re-use of nest sites within and between years. Nesting success was low. Of 15 nests with known outcomes, 4 were successful. Evidence collected at nest sites indicates that predation on eggs (n=8) and adults (n=2) were causes of nest failure.

SPATIAL DISTRIBUTION OF AND HABITAT SELECTION BY SEABIRDS AND WATERFOWL IN CENTRAL AND SOUTH SAN DIEGO BAY

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The seabird and waterfowl community of coastal southern California's San Diego Bay (Bay) is comprised of overwintering birds from temperate northern latitudes and breeding birds from tropical southern latitudes. The majority of these species utilize shallow water habitats in south and central Bay, and about a third are considered sensitive by federal and state governments. An intensive one year study of species richness, composition, relative abundance, spatial distribution, and habitat association across south and central Bay was conducted between April 1993 and 1994. Weekly surveys were conducted during four different two-hour survey time periods. Point locations of seabirds and waterfowl were recorded by boat using a modified version of the two receiving station, triangulation location method. Species, density, behavior, weather, number of water vessels, and time were recorded at each point location. Open water habitats were categorized by water depth and percent cover of eelgrass. Point locations and open water habitats were analyzed using Arc Info.(ver.7.04) on a Unix platform. A total cumulative count of 149,553 seabird and waterfowl point locations were recorded. Surf Scoter was the most abundant species with a cumulative count of 85,475, followed by lesser and greater scaup combined (14,169), Bufflehead (7,667), Brant (6,929), and Brown Pelican (3,577). Abundance of bottom feeders, including Surf Scoter, Scaup, Bufflehead, and Brant, was 53 % higher in south Bay compared to central Bay. Preliminary results from a habitat selection analysis using a chi-squared utilization test based on the Bonferroni inequality (Neu test) will be presented.

RISKS OF MAMMALIAN NEST PREDATION TO MARBLED MURRELETS

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We simulated 304 Marbled Murrelet nests and monitored their fates during the breeding seasons of 1995 and 1996. Small mammals (flying squirrels, Douglas squirrels, Townsend chipmunks, and deer mice) disturbed 20.7% of the nests. Mammals were more likely to disturb nests containing visual and olfactory cues associated with the nestling stage (nests contained

crudely preserved, dead domestic fowl chicks) than they were to disturb nests with inert artificial eggs. Laboratory experiments were conducted to investigate food preferences and predatory abilities of flying squirrels, Douglas squirrels, and deer mice (*Peromyscus oreas*). These experiments are ongoing, but initial results indicate: 1) Mice are unlikely to be important predators on murrelet nests because they only rarely open large, intact eggs (they readily scavenge slightly cracked eggs). 2) Douglas squirrels are unlikely to be important predators because they do not appear able to open large eggs and do not attack murrelet-sized chicks. 3) Flying squirrels are potential predators because they can attack and kill large nestlings (200g feral pigeon chicks). However, nestlings are not preferred prey items and may only be killed when squirrels are hungry and preferred foods are in short supply.

BREEDING BIOLOGY OF BRANDT'S CORMORANTS AT SAN NICOLAS ISLAND, CALIFORNIA

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Population size (1991-1995) and reproductive success (1992-1994) of Brandt's Cormorants (*Phalacrocorax penicillatus*) were studied at San Nicolas Island, California. San Nicolas Island is an active U.S. Navy base and currently hosts the largest Brandt's Cormorant colony in the Channel Islands. Breeding parameters varied annually due to a variety of factors. Breeding population size was highest in 1991 and 1993 and lowest in 1992 and 1995. Hatching, fledging and overall breeding success were depressed in 1992 due to human disturbance and intense El Niño conditions. Breeding success in 1993 was zero at monitored colonies due to predation by Island Fox (*Urocyon littoralis*) and possibly other factors, although successful re-nesting occurred very late at a new site. Reproductive success was highest in 1994 when human disturbance, predation, and El Niño were reduced. Overall, populations declined from 1991-1995 despite substantial increases since the 1970s. Colony-site switching was observed both within and between years and in some cases occurred after breeding failure. This switching behavior has occurred for several decades.

IMPACTS TO NESTING XANTUS' MURRELETS BY INTRODUCED MAMMALS

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Xantus' Murrelets are one of the rarest breeding seabirds in the North Pacific, with breeding colonies distributed only from southern California, U.S.A. to central Baja California, Mexico. Among the many threats, predation by introduced mammals has had the greatest impact on populations. Feral cats have been introduced on at least 13 known nesting islands, beginning in the late 1800s to early 1900s. Cats are believed to have exterminated (e.g., Todos Santos, San Geronimo, San Martin islands) or severely reduced several Xantus' Murrelet colonies, especially in Baja California. Cats probably depleted the now large colony at Santa Barbara Island before being eradicated in the mid-1900s. Black Rats (*Rattus rattus*) impact murrelets on Anacapa Island and probably other colonies. Goats and other feral grazers have eliminated potential shrub-

nesting habitat on several islands. Feral rabbits currently occur on at least two islands (and formerly one other) and probably destroy habitat and compete for nest sites. Increased human use of many islands may result in future introductions and impacts from human disturbance. Much additional information is needed to determine the distribution of active colonies, population size, and the true extent of these impacts including assessments of supposedly extirpated colonies. Introduced mammals should be eradicated from nesting islands.

NESTING OF ASHY STORM-PETRELS IN SEA CAVES AT SANTA CRUZ ISLAND, CALIFORNIA

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In 1995-1996, we located and monitored nests of Ashy Storm-Petrels (*Oceanodroma homochroa*) at Santa Cruz Island, California. Four of five study colonies were discovered recently in sea caves, a nesting habitat previously not well documented. Colonies were visited at three to four week intervals, from late April until late November. All nest sites were marked with metal tags. Adults were not handled in order to minimize disturbance. Accessible chicks were weighed, measured and banded. Egg laying extended from April to September, with peaks in June and July. Fledging began in August and continued beyond the study period, probably into January. To describe breeding phenology, egg laying and hatching dates were back-calculated using available literature and estimated ages of chicks when first noted. A variety of nest sites were used, ranging from crevices formed by rock and/or driftwood to relatively open sites on cave floors. These nest sites are fragile and require protection from human impacts. Storm-petrels nesting in sea caves are susceptible to human disturbance by noise and death/injury due to trampling during sea cave visits.

REDUCING SEABIRD BYCATCH IN SALMON DRIFT GILLNETS

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We compared seabird entanglement and salmon catch rates in modified gillnets across times of day (morning change of light, daytime and evening change of light) in an attempt to develop fishing gear and techniques that reduce seabird bycatch in salmon drift gillnets without significantly reducing salmon catch. Modified gear included monofilament gillnets with visible barriers of white opaque mesh replacing the upper 20 or 50 meshes of a traditional 200 mesh monofilament net and traditional monofilament nets equipped with acoustic alerts (pingers). Tests took place in the San Juan Islands area of North Puget Sound from 28 July to 29 August 1996. Preliminary data analyses indicate that seabird entanglement rates by gear type and time of day were species specific. Common Murre entanglement rates were similar (55.0% and 61.0% of control) in nets with 20 mesh and 50 mesh visual barriers, but Rhinoceros Auklet entanglement rates decreased with increasing depth of visual barriers, 57.9% and 21.8%, respectively. Pinger nets were more effective at reducing Common Murre entanglement rates (51.0% relative to the control) than Rhinoceros Auklet entanglement rates (80.7% of control). Common Murre entanglement rates were 2.3 and 2.2 times greater in morning and evening change of light sets than in daytime sets. Rhinoceros Auklet entanglement rates were 4.2 times

greater in morning change of light sets than in daytime or evening change of light sets. Applications of these findings to fisheries management, and further development of acoustic technology to reduce seabird entanglements, will be discussed.

ASSESSMENT OF IMPLANTABLE SATELLITE TRANSMITTERS FOR COMMON AND THICK-BILLED MURRES

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From 1995-96 we implanted 46 Common and Thick-billed murres with satellite transmitters, documenting over 3000 locations. Location accuracy averaged 0.77 ± 0.93 (s.d.) km from the estimated source, with 77% of the locations within 1 km. For each satellite pass, we averaged a 60-77% chance of receiving a signal and a 43-51% chance of obtaining a usable location from each transmitter. Of all locations received, about 22% were erroneous and had to be culled from the database. Information from this method revealed foraging ranges, consistent feeding areas, and migration routes. However, implantation increased mortality and affected the nesting behavior of the birds. After implantation in 1996, we compared presence at the colony, time spent at the colony, and nesting status between implanted murres and a control group. We found that implanted murres were much less likely to return to the colony, and that those that did return were less likely to breed successfully.

WATERBIRD SPECIES RICHNESS, DIVERSITY, AND HABITAT USE IN SAN DIEGO BAY

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Intensive waterbird surveys of San Diego Bay were conducted in 1993 and 1994. The bay was partitioned into three subareas: North, Central, and South Bay. A total of 60 species and over 343,500 individuals were recorded during all 142 surveys within the bay. Distinct differences in waterbird species composition, abundance, and habitat use were detected between subareas. Dominate species guilds were pelicaniform and larid species in North Bay; Surf Scoter, scaup, larids, and brant in Central Bay; and Surf Scoter, brant, and larid species in South Bay. The trend of indices of waterbird species evenness, richness, and diversity was generally North>Central>South. Each subarea supported substantial numbers of sensitive species, particularly in North Bay, which is dominated by man-modified/developed areas. The presence of bait barges, sheltered marinas, and piers with restricted human access in North Bay provided significant roosting and foraging habitat for many species, such as Brown Pelican. These structural characteristics are mostly lacking in the Central and South bay subareas, which are dominated by extensive areas of open shallow water habitats preferred by scoters, scaups and brant. Foraging guilds showed strong preferences for certain habitats types, with a general tendency for shallow water habitats being preferred over deeper water habitats.

EVALUATION OF THE EXTENT AND DURATION OF ALTERATIONS IN HEMATOLOGICAL AND SERUM BIOCHEMICAL PARAMETERS RESULTING FROM OIL EXPOSURE AND REHABILITATION

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Please refer to Anderson, D.W., et. al., Experimental Releases Of... for the study design.

In order to determine long term physiological effects of oil exposure and rehabilitation on avian species, 22 hematological parameters and 23 serum biochemical parameters for both rehabilitated (RHB) birds and control (CON) birds were examined at monthly intervals (April, May, June and July) after the Unocal-Metrolink oil spill (February 21, 1995). Analysis of variance was used to identify blood parameters which differed significantly ($p < 0.05$) between the RHB birds and CON birds. The majority of significant differences between RHB and CON birds occurred in April (less than 2 months after the spill) including: white blood cell count (WBC), mean corpuscular hemoglobin and mean corpuscular hemoglobin concentration, creatine kinase (CK), alkaline phosphatase, aspartate aminotransferase, alanine aminotransferase, calcium, total protein, globulin, and albumin:globulin (A:G) ratio. Values from RHB birds were lower than CON birds with the exception of WBC, A:G ratio and calcium concentration. Creatine kinase concentrations significantly differed ($p < 0.05$) in both April (CON>RHB) and July (RHB>CON). Abnormalities associated with liver enzymes, muscle enzymes, immunocompetence and red blood cells consist of the main alterations detected in this study. The biological significance of these results and their predictive value as it relates to long term post-release survival will be presented.

UTILIZATION OF BLOOD SAMPLING TO EXAMINE THE STRESS RESPONSE OF XANTUS' MURRELETS (*Synthliboramphus hypoleucus*) TO THREE DIFFERENT HANDLING PROTOCOLS

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Blood samples were collected from 108 Xantus' Murrelets captured on the water near Santa Barbara Island, California at night. Birds were transported to the research vessel and randomly assigned to one of three study groups. Group 1 murrelets were held in pet carrier boxes for 30 minutes, removed and bled. Group 2 murrelets were removed from boxes at 20 minutes post capture, measured and bled at 30 minutes. Group 3 murrelets were bled immediately upon arrival to the research vessel (within 10 minutes post capture). Blood samples were analyzed for stress indicators.

There were no significant differences between study groups for white blood cell counts or white blood cell estimates, lymphocyte, monocyte and eosinophil counts, packed cell volume or total protein. Corticosterone concentrations, heterophil counts, basophil counts and heterophil:lymphocyte ratios all showed significant differences ($p < 0.05$) between study groups. For all parameters, Group 2 murrelets had the highest concentrations while Group 3 murrelets had the lowest concentrations with the exception of heterophils where group 1 had the lowest counts. Preliminary results suggest that wild murrelets are stressed with being captured, but it

appears that the level of stress is not affected by an additional 10 minutes of handling. More work is necessary to determine if this "stress" has an affect on survivorship of murrelets.

POPULATION VIABILITY ANALYSIS OF THE ASHY STORM-PETREL (*Oceanodroma homochroa*) ON SOUTHEAST FARALLON ISLAND: STATUS, TRENDS, AND THE IMPACT OF PREDATION

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The Ashy Storm-Petrel is a rare species (<10,000 individuals world-wide), whose population is concentrated on Southeast Farallon Island (50 to 70% of the world population). It is currently a federally-designated Species of Concern. To assess its current status and future prospects, and to help design conservation and management plans, we carried out population viability analyses (PVAs) of the Southeast Farallon Island (SEFI) population based on empirical studies of this population, dating back to 1971. Earlier work (Sydeman et al. 1996) had determined that the breeding population in the main study area had declined 44% over a 20 yr period (1972 to 1992), this is equivalent to a constant 2.84% decline per year. We integrated published information, results from other species, and results of field studies on this population, to develop stochastic population models that reproduced the observed rate of decline. Field estimates of predation by Western Gulls on adults indicate mortality rates of 2.54%. If all such predation mortality were eliminated the population would be stable ($\lambda = 1.00$). Thus, elimination of gull predation is the key to population stabilization. We estimate that the total population of Ashy Storm-Petrels on SEFI in summer 1996 is about 3900 to 4900 individuals (aged 1 year or older); of these, about 2000 to 2800 are breeders.

RANDOMIZATION EVALUATIONS OF RADIO TELEMETRY AND STRIP TRANSECT METHODS OF SAMPLING HABITAT SELECTION BY BLACK-LEGGED KITTIWAKES

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We compared strip transect and telemetry methods of determining habitat selection by Black-legged Kittiwakes (*Rissa tridactyla*) in Prince William Sound, Alaska using randomization tests. The variables compared were distance birds were observed from shore and from their colony. We also used randomization tests to determine the effect of reducing our sampling effort for both methods. We evaluated factors that could bias either method and how they may affect the respective data sets. Telemetry data yielded significantly greater values for distance from shore measurements. We concluded that our assumptions of linear flight between telemetry locations had biased our results. Distance from colony values determined by telemetry were significantly greater than those obtained from strip transects indicating a decreasing probability of sighting birds at increasing distance from their colony had biased the strip transect data. We modeled declining probability of sighting birds at increasing distance from colony and compared model predictions to field data. The field data was consistently equal to or below the model predictions.

We concluded that telemetry provided a more representative measure of foraging distance than strip transects for colonial birds. Strip transect data had lower standard error values and our sampling effort could be greatly reduced and yield greater precision than the telemetry study. We concluded that greater precision could be obtained by using strip transect data for similar time investments.

RESTORATION OF COMMON MURRE COLONIES IN CENTRAL CALIFORNIA: FIRST YEAR'S EFFORTS RESULT IN EGGS AND FLEDGED CHICKS

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Efforts to restore the Common Murre (*Uria aalge*) colony at Devil's Slide Rock in central California were initiated in January 1996. Murre decoys (384 adult, 36 chick, and 48 egg), mirror boxes, and a sound system were deployed as elements of a social attraction effort to encourage Common Murres to recolonize Devil's Slide Rock. Less than 24 hours after decoy deployment one murre was observed visiting the former colony and 4 murres were present within 48 hours. Thereafter, attendance was constant and murre numbers increased throughout the season. A peak count of 29 murres occurred on 12 July. Six pairs of murres nested and 3 chicks successfully fledged. This is the first known breeding at Devil's Slide Rock in the last decade and is the first documented breeding in response to social attraction for murres in North America. We describe methods of artificial colony design, discuss aspects of social attraction, and compare attendance and breeding information collected at 3 other central California colonies.

SEARCHING FOR DINNER: ROADSIGNS, RESTAURANT REVIEWS, AND RELATIVE ABILITY

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During the chick-rearing period, seabirds are especially dependent on marine productivity, as they must feed both themselves and their chick(s). In inherently variable environments, such as the nearshore oceanic system, seabirds make use of a variety of cues to find food including oceanographic structures such as localized upwelling, surface slicks, and Langmuir troughs, as well as social mechanisms such as passive and active information transfer, and group foraging. This paper explores the links between Common Murres (*Uria aalge*) and their prey base, in the waters immediately surrounding the largest breeding colony in Washington State, Tatoosh Island. Murre distribution around Tatoosh is a function of both distance from the island (i.e. diffusion) as well as nekton density - a pattern also displayed by other Alcids breeding on the island. On the colony, murres feed their chicks a range of prey items, mostly schooling baitfish. Prey species selection appears to be in part individual-specific, although there are also significant influences of day, time of day, and selection by neighbors. Taken together, these data suggest that murres combine social skills with use of specific oceanographic features to locate food in a spatio-temporally patchy environment.

FEEDING ECOLOGY OF THE DARK-RUMPED PETREL IN THE EASTERN PACIFIC: TWO PERSPECTIVES AS DIFFERENT AS NIGHT AND DAY

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We collected information on the feeding ecology of Dark-rumped Petrel (*Pterodroma phaeopygia*) from 1913 sightings (2468 petrels) made during 24 research cruises (1976-1993). Most Dark-rumped Petrels (72%, 1783 petrels) were lone individuals which were not obviously involved in active feeding. In contrast to lone birds, most petrels recorded in groups were feeding (61%, 57 groups). Although we occasionally observed petrels scavenging at the surface, the vast majority of these feeding birds (93%, 53 groups) were in mixed-species flocks feeding on live prey. Flocks averaged 70 ± 17 birds and 4 ± 0.3 species, and were associated with subsurface predators on at least 28 occasions (53% of all feeding groups). The associated predators were tuna (minimum of 13 flocks), dolphins (21 flocks), and mixed schools of both (6 flocks).

Because hatchlings on Galápagos colonies are fed mesopelagic prey, Imber et al. (1992) understandably concluded that the Dark-rumped Petrel is a nocturnal feeder. Our research from ships at sea indicates that diurnal feeding is common and that this species is a member of the speciose seabird community that feeds in flocks and depends upon subsurface predators for feeding opportunities.

EVALUATION OF PIGEON GUILLEMOT NESTLINGS AS SENTINELS OF NEARSHORE OIL POLLUTION: RESULTS OF A CONTROLLED DOSE-RESPONSE EXPERIMENT

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Pigeon Guillemot nests in Kachemak Bay, Alaska were monitored during the 1994 and 1995 breeding seasons. Growth rates were measured and blood samples were collected from nestlings at 20, 25, and 30 days post-hatch. Baseline levels of various blood biomarkers were influenced by year, Julian date, location, and age. In 1995, a controlled dose-response experiment was conducted by feeding small amounts (0.05 ml or 0.20 ml) of weathered Prudhoe Bay Crude Oil to nestlings at 20 and 25 days post-hatch. Serum levels of haptoglobin, total protein, sodium, alanine aminotransferase (ALT), and aspartate aminotransferase (AST) were determined, as well as subsequent growth rates of body mass. No treatment effect was detected for total protein, sodium, ALT, and AST levels in sera, and growth in body mass was not different among treatments. Levels of haptoglobin differed among treatments, but there were significant location and provisioning rate effects that confounded treatment effects. These results suggest that doses were not sufficient to induce a persistent inflammatory response. Although more work needs to be conducted to assess its utility, haptoglobin may be a useful avian biomarker of recent exposure to anthropogenic contaminants.

GROWTH OF PIGEON GUILLEMOTS AS AN INDICATOR OF FORAGE FISH QUALITY AND AVAILABILITY

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Pigeon Guillemots appear to provision nestlings opportunistically from available nearshore demersal and schooling forage fishes. Because these fishes vary in availability, size, and energy density, growth of Pigeon Guillemot nestlings may serve as an indicator of nearshore conditions. Aspects of guillemot diet were measured in Kachemak Bay, Alaska during the 1994 and 1995 breeding seasons. Taxonomic composition of diet and prey delivery rates to nestlings varied widely among breeding sites; proportion of sand lance (*Ammodytes hexapterus*) in diets varied from 2 to 86%. Prey delivery rates were influenced by location, tide stage, brood size, brood age, and a brood size location interaction. Growth rates increased with proportion of sand lance in the diet, but not with prey delivery rates. This suggests that availability of schooling forage fishes with high lipid content (e.g., sand lance, herring) may have a significant influence on guillemot productivity. Comparisons with guillemots breeding on Naked and Jackpot islands, Prince William Sound support this inference. Growth rates at Jackpot Island were higher than at Naked Island, especially in a year when herring was a major component of the diet. Diets at Naked Island were mostly blennies, with few sand lance or herring.

WITHIN-SEASON CHANGES IN DENSITY OF MARBLED MURRELETS OFFSHORE OF THE SAN JUAN ISLANDS, WASHINGTON

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We surveyed for Marbled Murrelets from small boats using 16 line transects located 300 m offshore of 8 islands in the San Juan Archipelago of Washington. Transects, which totaled 170 km, were repeated during 7 10-day intervals beginning 24 June and ending 31 August, 1996. We estimated distance to each bird or group of birds and used program DISTANCE to calculate detection functions and density estimates for each sample period. Density varied from 6.6 to 7.3 birds/km² in periods 1 to 3 and increased to 16.2 to 19.3 birds/km² in periods 5 to 7. Assuming a closed population, these results are consistent with expected trends: numbers of adults were augmented by fledged juveniles as the breeding season progressed. We do not know whether the population is closed, as new adults may be immigrating from outside our study area. Further work to correlate density in our area to that in surrounding areas, along with independent estimates of juvenile productivity, will help test this assumption.

INTRODUCTION AND OVERVIEW OF *CEPPHUS* SYMPOSIUM

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Guillemots (*Cephus* sp.) may be well-suited as avian bioindicators of the status of coastal ecosystems. This symposium explores the potential for using nesting guillemots to monitor

variation and perturbations in nearshore ecosystems, including annual variability in demersal and forage fish resources, presence and levels of contaminants, regional oceanographic and climate change, and other factors affecting the status of nearshore ecosystems. The following traits enhance guillemots as potential indicators: (1) most neritic members of the marine bird family Alcidae; (2) common, widespread, and homogeneous seabird genus; (3) nest in small, widely-scattered colonies; (4) frequently nest site- limited but plastic to nest site requirements, allowing for the expansion or creation of study colonies by providing artificial nest sites; (5) adults typically have high annual survivorship and high nest site fidelity, allowing both long term monitoring and an indicator of winter conditions in the nearshore; (6) raise one- or two-chick broods that are fed almost entirely on fish and remain in the nest cavity until adult size; (7) provision young with whole fish carried in the bill so prey items can be identified, measured, and, if necessary, collected for contaminant analyses; (8) forage mostly within 5 km of the nest site in subtidal and nearshore zones; (9) prey opportunistically on a diverse assortment of subtidal and nearshore demersal fishes (blennies, sculpins), as well as schooling forage fishes (sandlance, herring, pollock, arctic cod).

BEACHED BIRD AND MAMMAL SURVEYS ALONG THE CENTRAL CALIFORNIA COAST

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In 1993, the Gulf of the Farallones National Marine Sanctuary began Beach Watch, a long term monitoring program documenting numbers of live and beached (dead) birds and mammals, oil and tar ball deposition, and human activities along coastal beaches. Currently, surveys of 58 beach segments are conducted every two or four weeks, from Bodega Head, Sonoma County to Point Año Nuevo, San Mateo County. Beach Watch is designed to be a pre-spill baseline monitoring project, after Carter and Page (1989) post-oil spill survey program. Data on beached birds and mammals, from 12 beach segments with the longest coverage (October 1993 - June 1996), are presented. Forty-nine bird and eight mammal species were documented. Average annual deposition rate of birds during the winter (December - February) was 0.76 birds/km and 0.09 mammals/km; spring (March - May) 0.78 birds/km and 0.11 mammals/km; summer (June - August) 0.89 birds/km and 0.08 mammals/km; fall (September - November) 1.17 birds/km and 0.22 mammals/km.

OILED BIRD AND TAR BALL DEPOSITION RATES FOR THE CENTRAL CALIFORNIA COAST

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In 1993, the Gulf of the Farallones National Marine Sanctuary began Beach Watch, a long term monitoring program of live and beached (dead) birds and mammals, oil and tar ball deposition, and human activities. Beach Watch is designed to be a pre-spill baseline monitoring project. Shipping lanes for a major west coast sea port for oil tankers (San Francisco Bay) run through the center of the survey area. Beach habitats varied and included sandy dune, creek mouths, and sandy coves along headlands and cliffs. Data from 12 beach segments (25.5 km) with the longest

coverage (October 1993 - June 1996), are presented. Of the 49 beached bird species found during the study period, five were found oiled: Cassin's Auklets, Common Murre, Northern Fulmar, Pacific Loon and Pink-footed Shearwater. One gull species and one shorebird species were also found oiled. Percent of beached birds which were found to be oiled was 2.2%. Tar ball deposition concentrated in two areas, Drake's Beach and Limantour Beach, with 1.05 tar balls/km and 1.81 tar balls/km, respectively. Oiled beached bird deposition did not correlate with tar ball deposition zones.

USING ARTIFICIAL NEST BOXES TO STUDY BONIN PETREL BREEDING BIOLOGY

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Artificial nest boxes were used to study Bonin Petrels on Sand Island, Midway Atoll from 1994-1996. Nest boxes consisted of a plywood box with a cover that opens like a trap door. PVC pipe, cut to 0.5, 1.5 or 2.0 m, was used as a tunnel for each box. I monitored boxes daily from January through June 1994, 1995 and 1996 to monitor incubation shifts, feeding frequency, chick growth, mate and nest site fidelity. During all three years, nesting birds used 15 of 30 boxes, 6 of which were single birds incubating eggs. Three pairs of birds returned to nest in the same nest box for three consecutive years, and one pair for two consecutive years. One pair bred in the same box in 1994 and 1996 only. Mean incubation shift was 7.07 days (range: 1-14 days). Average shift by females was 6.2 days (range: 1-12 days) and males 8.11 days (range: 1-14 days). Mean feeding frequency was one feeding every 1.93 nights. Mean maximal mass was 282.4 g and occurred in 67 day old chicks, after which, mean chick mass declined until fledging. Fledging occurred at a mean age of 83.8 days and at a mean mass of 187.8 grams.

MORTALITY OF LAYSAN AND BLACK-FOOTED ALBATROSSES IN THE HAWAII PELAGIC LONGLINE FISHERY

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Laysan and Black-footed albatrosses are being killed during interactions with longline gear of boats fishing for tuna and swordfish in the central North Pacific at rates comparable to or exceeding hooking rates for seabirds on longlines in the southern ocean. National Marine Fisheries Service observers recorded interactions of marine mammals, turtles, and birds on 4% of the longline fishing trips taken by boats registered in Hawaii in 1994 and 1995. Laysan Albatross were hooked at a rate of 0.113 birds per 1000 hooks and Black-footed Albatross at a rate of 0.152 birds per 1000 hooks. Estimates ($\pm 95\%$ C.I.) of total take made using a design stratified by fish target species were 1020 ± 639 Laysans taken in 1994 and 1942 ± 2435 taken in 1995. We estimate that 2135 ± 970 Blackfoots were hooked in 1994 and 1796 ± 1498 in 1995. Numbers of northern hemisphere albatrosses being killed in this fishery are part of the overall mortality due to pelagic longlining by other nations and demersal longlining in Alaska. Estimates of mortality for Black-footed Albatrosses (world population = 58,500 breeding pairs) have triggered concern in the managing agencies and the Fishery Management Council.

A COMPARISON OF THE BREEDING BIOLOGY OF THE THREE *CEPPHUS* SPECIES

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The two common species of guillemot, the Black Guillemot (*Cepphus grylle*) and Pigeon Guillemot (*C. columba*), are believed to be similar in many aspects of their breeding biology and demographics. Although separated for 2.8 mybp (V. Friesen unpubl. data) they remain remarkably similar, due in part to maintaining generalist strategies. Only recently have studies been conducted on the breeding biology of their congener, the Spectacled Guillemot (*C. carbo*), restricted in its distribution to the Sea of Okhotsk. While scientists have generally assumed that information on one species can be applied to the entire genus, until now data on the breeding biology of the Spectacled Guillemot were insufficient to allow validation of comparisons. Using data from our recent studies of all three species, we compare their breeding biology to determine the similarity of the Spectacled Guillemot to its congeners. Examination of breeding chronology, egg size, clutch size, incubation and nestling period, fledgling mass (percent of adult mass), nestling diet, growth rates, and impacts of predation show differences among the three species are small or undetectable in our study populations. Differences that do exist may best be explained by differences in adult size, nesting habitat, and prey type and abundance.

DOVEKIE, A PROBABLE BREEDER ON SAINT LAWRENCE ISLAND, ALASKA

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The breeding range of the Dovekie (*Alle alle*) is restricted to the high-arctic marine zone with principal colonies located in the North Atlantic. The total breeding population is estimated at 12 million (range: 8-18 million). In contrast, only a few observation records exist for the Bering Sea. A seabird survey along the north shore of Saint Lawrence Island was conducted from June 28 to August 5, 1996. One Dovekie pair was observed for 1.25 hours on 27 July at Singikpo Cape auklet colony. The probable nest site was a talus slope 1.4 kilometers inland at 145 meters elevation. While I photographed, the pair repeatedly flushed, circled and returned to the site. I will present a video and slides that document behavior and habitat.

FORAGING OF MALE MAGELLANIC PENGUINS DURING INCUBATION AND CHICK REARING: NEW RESULTS USING SATELLITE TELEMETRY

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We used satellite telemetry to determine foraging locations and behaviors of two male Magellanic Penguins breeding at Punta Tombo, Argentina. Both birds were experienced breeders--both banded as breeders more than 10 years prior to this study--and both had eggs or chicks in their nests during the study. One male swam to a location more than 500 km NE of the breeding colony during a 26 day foraging trip. The second male, which we monitored from the time of the first male's second trip, swam over 150 km to the ENE on a nine day foraging trip. This male also followed its first route on a subsequent shorter trip. In addition to foraging in different locations, the males exhibited different foraging patterns. During the period when the first male took one 18 day foraging trip, the second took six trips averaging 3.7 days in length.

Furthermore, although most dives of both birds were very shallow (≤ 10 m), the remaining dives of the first male were spread approximately equally across depths of 10-20, 20-40, and 40-80 m, while the dives of the second bird were concentrated at depths greater than 40 m. These results, although preliminary, suggest that Magellanic Penguins forage farther from breeding colonies than was previously suspected and that individuals follow particular foraging strategies.

POPULATION DYNAMICS OF KITTIWAKES IN PRINCE WILLIAM SOUND, ALASKA: DO CHANGES IN PRODUCTIVITY AT INDIVIDUAL COLONIES SUPPORT OVERALL POPULATION TRENDS?

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The nesting population of the Black-legged Kittiwake (*Rissa tridactyla*) in Prince William Sound (PWS) has remained relatively stable from 1972 to 1989. From 1989 to 1995 the nesting population increased, although productivity significantly decreased compared with 1984 to 1989. Abundance of breeding pairs at individual colonies ($n = 27$) within PWS, however, has undergone drastic fluctuations. Numbers of nests built at 15 colonies decreased by 7.1% to 100% (Boswell Rocks colony decreased from 4936 to 933 pairs). In contrast, 12 colonies increased by 40.3% to 3775% (Shoup Bay colony increased from 195 to 5628 pairs). Annual increases at some colonies were due to immigration and could not have been supported by recruitment from that colony (e.g. Seal Island had a maximum of 67 pairs prior to 1995 and 252 pairs in 1995). Conversely, some colonies declined at rates that may not be explained by adult mortality alone, indicating emigration. Further analyses of these data will assist in determining the extent of immigration and emigration among colonies and if productivity within PWS is sufficient to maintain population trends.

WHAT IS KNOWN AND UNKNOWN ABOUT THE POPULATION DYNAMICS OF XANTUS' MURRELETS ON SANTA BARBARA ISLAND, CALIFORNIA: THE MOUSE FACTOR

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We developed a stochastic population dynamics model and viability assessment based on known and estimated demographic characteristics to evaluate the causes of apparent population decline of Xantus' Murrelets on Santa Barbara Island, California. Based on surveys by Hunt et al. (1979) and Carter et al. (1992), we established 3 scenarios in which the population declined by as little as 29.9% or by as much as 71.8% over the period 1977-1991 (i.e., $\lambda = 0.975$, $\lambda = 0.947$, and $\lambda = 0.914$, respectively). Empirical studies conducted by the CINP Seabird Monitoring Program from 1983-1995 on reproductive performance indicated substantial inter-annual variability in hatching success (13 year mean $\lambda = 0.813$), determined primarily by mouse (*Peromyscus maniculatus*) predation on eggs. We estimated the population trajectory, time to population halving, and probability of the breeding population reaching 500 breeding individuals (i.e., a critical level of endangerment or "quasi-extinction") using program *RAMAS/METAPOP*. Assuming $\lambda = 0.975$ (Scenario I), within 10 years there was $< 20\%$ chance of the population halving and 0-6% chance of the population reaching "quasi-extinction"; within 20 years the probability of "quasi-extinction" increased to 24-28%. Assuming $\lambda = 0.947$ (Scenario II), within 20 years the

probability of "quasi-extinction" increased to >70%, indicating a grave situation. Mouse predation would need to be reduced by 26% or 61%, respectively, to achieve population stability under Scenarios I and II.

RECENT COMMON MURRE (*Uria aalge*) POPULATION TRENDS BASED ON DIFFERENT METHODS AT THE SOUTH FARALLON ISLANDS, CALIFORNIA

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We used ground/boat (1979-1995) and aerial photographic (1985-1993) survey techniques to estimate the breeding population size of Common Murres on the South Farallon Islands, the largest colony of the central California population. In addition, "index plots" (n=9, the number of adults censused during peak incubation) and two intensive "study plots" (number of egg-laying sites determined) provided data for comparisons between all-island and sub-colony population trends. After a dramatic decline from 1982-1986, numbers of breeding murres remain in a depleted state owing to a variety of factors including impacts from past and continuing oiling, gill-net mortality, lower recruitment due to ENSO events, and changes in prey base. Between 1987 and 1989 numbers remained relatively stable at $\pm 40-45K$. In the early 1990s, however, the population experienced limited growth, interrupted by the 1992 ENSO. As of 1995, the ground/boat survey indicated a population of $\pm 65K$. Ground/boat survey results are comparable to aerial survey results when counting birds from high vantage points, but aerial surveys are vastly superior (obtaining estimates of 50-100% more birds) when counting from below colonies (e.g., from sea) or from great distances. Index and study plots indicated slow growth in the late 1980s and more growth in the 1990s, but numbers in only one index plot grew substantially. All-island vs sub-colony data provide complementary information. The strength of this long-term monitoring program is extensive sampling (both spatially and temporally), and replication which has served to corroborate results obtained using various techniques.

AT-SEA DISTRIBUTION OF XANTUS' MURRELETS IN THE SOUTHERN CALIFORNIA BIGHT: LESSONS FROM A TELEMETRY STUDY

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We radio-marked 110 Xantus' Murrelets (*Synthliboramphus hypoleucus scrippsi*) at Santa Barbara Island in the Southern California Bight from April to May, 1995-1996. Radio-marked birds were relocated from a telemetry tower on the island and from aircraft flying transects between Mexico and Point Conception. We detected murrelets 1,059 times (N=43 birds) from the tower. Many (39%) murrelets returned to the island after marking. We recorded 3.8 ± 2.8 at-sea locations per murrelet in aerial surveys and relocated them for 10.0 ± 9.6 days. Mean distance between locations was 46 ± 34 km (2-223 km). In 1996, murrelets marked in April were distributed north of Santa Barbara Island from Point Dume to San Miguel Island. Murrelets marked in May were concentrated south of San Nicolas Island. Previous studies indicated

murrelets were highly concentrated within 20 km of Santa Barbara Island from March to May. We found radio-marked murrelets distributed 35-95 km from the island, although many may have been nonbreeders. Murrelets returning to the island after marking were relocated 52 ± 19 km away, indicating longer foraging distances from the colony than previously reported.

NESTING PHENOLOGY OF BLACK SKIMMERS IN CALIFORNIA

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Black Skimmers (*Rynchops niger*) have nested in California since 1972. Their population has increased to nearly 1200 pairs in 8 colonies by 1996. In several cases they are nesting in association with terns, particularly Caspian (*Sterna caspia*) and Elegant terns (*Sterna elegans*). In contrast to the terns, Black Skimmers often show a prolonged breeding season with new nests sometimes being initiated as late as September. Year to year variation within and between colonies is extensive. Interspecific interactions may explain some of this variation.

VARIABILITY OF THE BILL-LOADS OF RHINOCEROS AUKLETS : A SAMPLER OF FORAGE FISH?

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Rhinoceros Auklets feed mainly on forage fish during their chick rearing season. As size and fish composition of their bill-loads show great variability, they have been thought to be a good sampler of forage fish. However, parents of some alcid species increase foraging effort under poor food availability and their food provisioning is controlled by food demand of chicks also. We have been monitoring bill-loads and chick growth of Rhinoceros Auklets at Teuri Island for eight years. As the recent increase of the availability of Anchovy (*Engraulis japonica*) causes improvement of chick growth of this species through the increase of bill-load size, they seem to be a good sampler of forage fish. To evaluate the effects of food demand of chicks on short-term variability of their bill load size, we also examined 1) daily variation of bill-load size through the growth of chicks and 2) response of parents to experimental manipulation of chick food demand. Chick growth and experimental manipulation of food demand of chicks did not affect variability of bill-load size: indicating that the parents did not adjust bill-load size to food demand of chicks.

Posters

CAPTURE, RECAPTURE AND DEMOGRAPHY OF MARBLED MURRELETS IN DESOLATION SOUND, BRITISH COLUMBIA

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From 1991 to 1996, 493 adult Marbled Murrelets have been banded in Desolation Sound (Theodosia Inlet), British Columbia. Theodosia Inlet is a flight corridor between forest nesting areas and marine foraging areas and murrelets can be reliably captured using mist nets on rafts. In total, 20 banded individuals have been recaptured at this site in subsequent years and 13

individuals have been recaptured in the same year they were banded. In 1995, we recaptured a bird banded in 1991; thus, it was at least 5 years old. In 1996, we banded 95 murrelets and recaptured 10 individuals which we had banded previously. This provides the first definitive evidence of fidelity to breeding areas for individual Marbled Murrelets. In September 1996, a bird which we had banded in 1995 was recaptured in northern Washington by American researchers. This is the first recapture of an individual at a location other than its breeding area. The demographic focus of our banding program is augmented by radio telemetry, radar censuses, collection of DNA (blood samples) for sex determination and color marking of individual murrelets.

DISTRIBUTION AND ACTIVITY PATTERNS OF THE MARBLED MURRELET IN DESOLATION SOUND, BRITISH COLUMBIA

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A marine survey route was designed to study the distribution, abundance and activity patterns of Marbled Murrelets in Desolation Sound and the associated fjords. I conducted regular surveys from April to August of 1996. The pattern of abundance during the day changed over the breeding season. Early in the season, murrelets were more abundant in the morning. In contrast, later in the season, murrelets were more abundant in the afternoon. I will investigate relationships between breeding season chronology, group size and behaviour of murrelets with respect to the abundance patterns observed. In addition, Marbled Murrelets were captured using a system of floating mist-nets. All captured birds were marked with picric acid dye and some were individually marked with different combinations of radios, wing tags, and nasal disks. I tracked birds from the water and from the air to determine distribution and movement of individuals. Resightings of marked birds demonstrates that some individuals remained in Desolation Sound throughout the season. Body and wing moult was also observed among marked and unmarked birds. I assess effects and feasibility of using these markers for Marbled Murrelet population studies.

ORGANOCHLORINE PESTICIDES AND PLANAR CHLORINATED HYDROCARBONS IN DOUBLE-CRESTED CORMORANTS FROM THE COLUMBIA RIVER ESTUARY

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The Columbia River receives numerous contaminants from permitted municipal and industrial discharges, nonpoint pollution, accidental spills, and hazardous waste sites. Organochlorine contaminants have been associated with poor reproductive success in resident Bald Eagles (*Haliaeetus leucocephalus*). Elsewhere in the United States, Double-crested Cormorants (*Phalacrocorax auritus*) have been used as sensitive indicators of exposure to organochlorine compounds. The Columbia River estuary supports over 4,000 pairs of nesting cormorants which are exposed to and potentially harmed by organochlorine contaminants. We collected cormorant eggs from colonies in the estuary over a four-year period, and in 1993 from a reference colony, to

determine concentrations of organochlorine pesticides, polychlorinated biphenyls (PCBs), dioxins, and furans. Concentrations of chemical constituents were generally highest at the upstream island location in the Columbia River. Dioxin and furans were elevated in eggs from the Columbia River islands and were below detection in the reference colony. Dioxin-like compounds in Columbia River eggs were similar to concentrations associated with reproductive impacts in other species. DDE residues were higher ($P = 0.003$) in 1993 eggs from the Columbia River islands than the reference colony. Results of the H4IIE bioassay conducted on eggs in 1993 indicated the TCDD-Equivalents present in tissue would relate to a 23% egg mortality when compared to dose-response relationships developed for cormorants in the Great Lakes.

DISTRIBUTION AND DENSITIES OF PREDATORS OF MARBLED MURRELETS ON VANCOUVER ISLAND

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We recorded the occurrence and relative densities of potential predators (eagles, falcons, accipiters, corvids and squirrels) of Marbled Murrelets (*Brachyramphus marmoratus*) over five summers (1992-1996) in coniferous forest in Carmanah and Walbran watersheds on Vancouver Island, British Columbia. Data came from two-hour dawn surveys designed to record the activities of murrelets. The combined density of all predators was high at the coast, but at inland stations there was no correlation with distance from the coast. At inland stations, the percent occurrence and relative densities of Steller's Jays (*Cyanocitta stelleri*), Common Ravens (*Corvus corax*), and all predators combined were significantly higher at seven disturbed stations (situated at the edge of clearcuts or roads) than at 17 stations in undisturbed old-growth forest. Within disturbed habitats the occurrence and densities of jays were highest at four stations most frequently used by hikers and campers. Owls (five species) and Red Squirrels (*Tamiasciurus hudsonicus*) were not significantly affected by habitat disturbance or degree of human visitation. Predation at nests of Marbled Murrelets, and other forest-nesting birds appears more likely at the coast, and near clearcuts and roads, than at other sites.

FACTORS AFFECTING THE DISTRIBUTION AND RELATIVE ABUNDANCE OF MARBLED MURRELETS DURING THE BREEDING SEASON AT BIG BASIN REDWOODS STATE PARK, CALIFORNIA

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We established five intensive survey stations within old-growth forest habitat of the park and conducted five surveys at each site in 1995 and 1996 as part of a study investigating murrelet use of the park and nest success. Concurrently, another data set on detections was obtained via dawn stakeouts of potential nest trees. We considered three primary influences on detection levels and occupied behaviors: forest structure, corvid abundance, and prey availability. Forest characteristics were quantified through vegetation surveys, corvids were assessed through point counts, and prey availability was inferred from indices of prey abundance. The interplay of these

factors will be discussed. Low sample sizes may preclude definitive conclusions, but our preliminary assessment is that murrelet use of the park is highly variable in space and time, and use of different observers can increase variance in detection levels. The stand center had the highest detection levels each year even with high corvid abundance, but forest structure, topography, the confluence of streams, and stand edge interact to influence detection levels and occupied behaviors. This data will be useful in designing a monitoring plan and a general plan for the park.

SEABIRD, MARINE MAMMAL, AND OCEANOGRAPHY COORDINATED INVESTIGATIONS (SMMOCI) NEAR ANNUAL SEABIRD MONITORING SITES IN ALASKA

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Seabird monitoring has become one of the main sources of information about changes in the marine environment. To understand reasons for fluctuations observed in populations and productivity of indicator species at breeding colonies, it is important to understand the marine habitats upon which these species depend. Scientists studying Steller sea lions (*Eumetopias jubatus*) at breeding rookeries have similar objectives. Recently, a partnership has been developed among the authors and their organizations to characterize the marine environment within the average foraging range of seabirds (25-40 km depending upon target species) around designated sites on the Alaska Maritime National Wildlife Refuge where time-series data are being collected for seabirds and sea lions. Specific objectives include: 1. Estimate biomass of potential seabird and marine mammal prey, 2. Identify common prey organisms, 3. Assess oceanographic characteristics of water masses, 4. Characterize bottom fauna, 5. Record feeding distribution of birds and marine mammals, 6. Assess food web relationships. Examples of results from several sites in the Gulf of Alaska are presented.

THE USE OF RADAR TO MONITOR CASSIN'S AUKLET ACTIVITY PATTERNS

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We investigated the utility of radar for censusing and gauging activity of burrow nesting seabirds. Radar images of Cassin's Auklet were videotaped during 22:30 - 0400 during 30 April to 11 May on Triangle Island, British Columbia. We used a video image analysis system to analyze activity patterns by sampling the video at 30 second intervals. Activity rates increased as peak hatch approached. Abundance in the sampling area was conservatively estimated. Nightly activity patterns were also investigated. We evaluate the potential application of radar as a non-destructive method for estimating numbers of burrow nesting seabirds.

DIURNAL FEEDING PERIODICITY OF THE TERNS AND SKIMMERS NESTING AT THE BOLSA CHICA ECOLOGICAL RESERVE IN SOUTHERN CALIFORNIA

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The daily pattern of foraging by Caspian Terns, Elegant Terns and Black Skimmers nesting at the Bolsa Chica Ecological Reserve in coastal Orange County, California was examined by recording the numbers of birds returning to the colony with fish over dawn-dusk periods during 13 weekly visits to the reserve. Based on previous observations and known patterns of diurnality in two of the species (Caspian Terns and Elegant Terns) and nocturnality in the Black Skimmer, we tested the hypothesis that each species delivers fish to its chicks with different frequencies at different times of the day. The observation day was divided into four time periods: 0600-0900, 0900-1300, 1300-1700, and 1700-2000. The number of returns did not vary with time period for Caspian Terns. Elegant Terns showed a significant peak in the first (morning) time period. The Black Skimmer showed two significant peaks, in the first and last (morning and late afternoon) time periods, reflecting their nocturnal lifestyle. This study was conducted concurrently with a study on Elegant Tern and Caspian Tern chick provisioning on the nesting island, and should provide further information on the foraging patterns of breeding seabirds.

ATTENDANCE PATTERNS, PRODUCTIVITY, AND EFFECTS OF DISTURBANCE TO COMMON MURRE (*Uria aalge*) POPULATIONS AT POINT REYES NATIONAL SEASHORE

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We surveyed six small Common Murre sub-colonies at the Point Reyes Headlands, Point Reyes National Seashore, Marin County, California in 1995 and 1996. This study was initiated to investigate the effects of disturbance to local murre populations in the wake of a small shipwreck and subsequent rescue operations. In 1995, one sub-colony was abandoned, and three other sites experienced reduced productivity due to disturbance by Brown Pelicans and predation by Western Gulls and Common Ravens. In 1996, the same sub-colony was abandoned, due to an unknown disturbance. Daily attendance in stable colonies in 1996 fluctuated widely until the onset of egg-laying in early May, and then remained stable until early July, when non-breeders joined the colonies in high numbers. Diurnal attendance varied between days within colonies and between colonies within days. Several disturbances were documented in 1996, including the presence of a pinniped in one sub-colony and disruptions by Brown Pelicans at several sites. A study plot was established at one site, but we were unable to monitor breeding sites to derive productivity estimates. Nonetheless, it is clear that productivity at these coastal colonies is substantially lower than that observed at the nearby offshore Farallon Islands. Future studies are needed to establish year-to-year variations in attendance and to compare such patterns with results from other studies.

BLACK-CAPPED PETRELS TRACK PULSES OF UPWELLING WITHIN GULF STREAM MEANDERS

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Although a number of long-term studies have demonstrated that pelagic seabirds associate with water masses, none have examined whether the distributions of seabirds consistently shift in

relation to real-time changes in the position of physical oceanographic features. In addition, the processes that underlie associations between seabirds and water masses have often been unclear. I studied seabirds off the coast of North Carolina during the spring-fall seasons (May-September) of 1992-1995. Black-capped Petrels (*Pterodroma hasitata*) were most abundant in interior Gulf Stream waters and appeared to track the Gulf Stream's position. Furthermore, Black-capped Petrels were almost twice as abundant on days in which the Gulf Stream front moved offshore as on days in which the position of the Gulf Stream remained stable or moved onshore. Offshore movement of the Gulf Stream results from the passage of low-pressure troughs of Gulf Stream meanders, a process which induces upwelling within the Gulf Stream. Thus elevations in petrel abundance coincided with processes of upwelling, illustrating that investigations of current movement can expose patterns in seabird movement that current position cannot.

HABITAT CHARACTERISTICS, PROVISIONING RATES AND CHICK GROWTH IN BLACK OYSTERCATCHERS IN THE STRAIT OF GEORGIA, BRITISH COLUMBIA

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We initiated a study of habitat use and reproductive characteristics of Black Oystercatchers. We located and monitored 35 nesting territories during April through August 1996, in the Southern Gulf Islands, Strait of Georgia, British Columbia. Habitat use, nest site characteristics (n=33) and nest histories (n=31) were recorded. Provisioning rates were measured for a subset of territories (n=12) within the study site. Chick growth was measured for all successful territories (n=22), and chicks (n=41) were monitored until fledging (n=15). We examine patterns of provisioning rates, chick growth and fledging success in relation to habitat characteristics.

DIETARY BREADTH AND OVERLAP IN TERN AND SKIMMER COLONIES NESTING AT THE BOLSA CHICA ECOLOGICAL RESERVE AND THE WESTERN SALT WORKS IN SOUTHERN CALIFORNIA

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Food habits and foraging locations of Caspian, Elegant and Forster's terns and Black Skimmer nesting at the Bolsa Chica Ecological Reserve in coastal Orange County and the Western Salt Works in south San Diego Bay were analyzed for the 1995 breeding season based on fish dropped by the birds and on pellets regurgitated mainly by Caspian Terns. The colonies as a whole at both sites fed mainly on clupeoid fishes, especially northern anchovy and Pacific sardine, and atherinid fishes, especially topsmelt. Black Skimmers had the broadest diet and delivered the smallest prey at both sites. Caspian Terns foraged widely in marine, bay-estuarine and freshwater habitats and delivered the largest prey at the Salt Works, whereas Elegant Terns fed mostly in the ocean on northern anchovy and delivered the largest prey at Bolsa Chica. Within-site dietary overlap was limited by a combination of differences in prey type, prey size and foraging habitat but between-site overlap was uniformly high for each bird species. Limited historical data at the two sites suggest that dietary changes reflect shifts in prey abundance.

SURVIVAL RATES OF CRESTED, LEAST, AND WHISKERED AUKLETS AT BULDIR ISLAND, ALASKA

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Estimates of demographic parameters such as adult survival rate are urgently required for auklet species, which are the most abundant seabirds of the Bering Sea. To address this need, Crested ($n = 577$) and Least auklets ($n = 191$) were captured by day using noose carpets set on display rocks in their breeding colony at Buldir, marked with unique combinations of three Darvik plastic colour bands and a stainless steel band, and survival estimates were derived from resightings during 1990-1996. Whiskered Auklets ($n = 280$) were captured at night using mistnets to intercept birds arriving at their nesting crevices, marked with steel bands, and survival was inferred from recaptures during 1992-1996. Survival estimates were calculated using the SURGE (Survival Generalized Estimation) program. Our estimates of survival averaged about 75% in Least Auklets, 80% in Whiskered Auklets and 85% in Crested Auklets. For all species, survival fluctuated significantly from year to year, possibly due to changing environmental conditions. However, the three species did not vary in concert, suggesting that factors responsible for the variation in adult survival differ among auklet species.

ADJUSTMENT OF PARENTAL PROVISIONING EFFORT BASED ON CHICK CONDITION IN RHINOCEROS AUKLETS

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Previous research indicates that some seabird parents alter provisioning rates based on the age and size of their chick. I investigated the ability of Rhinoceros Auklets parents to adjust feeding rate according to variation in nestling condition on Triangle Island, British Columbia. Mass at age was used as an index of condition. In the experimental treatment, chicks of different mass but same age were exchanged. In the control group, nestlings with the same age and mass were exchanged. I compare provisioning rates prior to and following the exchanges by measuring the daily mass increments of the chicks. I will also test for differences in provisioning rates to male and female nestlings with the aid of a novel molecular technique to determine gender.

A COMPARISON OF CASSIN'S AUKLET EGG SIZE AND CHICK GROWTH BETWEEN YEARS AND SEXES, TRIANGLE ISLAND, BRITISH COLUMBIA

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Evidence exists for a positive relationship between egg size and offspring fitness in early chick-rearing. However, slow growing nestlings from smaller eggs may exhibit compensatory growth in the later rearing period. I examine the relationship between chick growth and egg volume between the years 1994, 1995 and 1996. Using a molecular technique to sex the 1996 chicks, I will describe how chick growth and egg volume differs between the sexes. I will demonstrate that even though chick growth was significantly different between years, egg volume did not differ. This study was carried out on Triangle Island, located 45 km northwest off the north end of Vancouver Island, which supports over a million Cassin's Auklets making it the largest colony of this species in the world.

SPRUCE BEETLE: A SERIOUS THREAT TO MARBLED MURRELETS IN ALASKA ?

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Throughout their range, Marbled Murrelets have lost old-growth forest nesting habitat because of logging. In Alaska, a new threat is the rapid loss of large spruce (*Picea spp*) trees to infestation by spruce beetles (*Dendroctonus rufipennis*). Currently, spruce on about 3 million acres in southcentral Alaska have been killed by beetles. Some affected forests are probable or known Marbled Murrelet nesting areas, including coastal areas of Cook Inlet, Kachemak Bay, the Kenai Peninsula, and northern Southeast Alaska. Beetle infestation has expanded dramatically in the past decade, and has caused upwards to 90% mortality of many coastal old-growth stands in Kachemak Bay. Preliminary surveys in Kachemak Bay suggest that murrelet productivity may be affected due to loss of nesting habitat. Juveniles were observed at sea throughout the bay in surveys conducted in 1988 and 1989. In 1996 only 1 possible juvenile was observed in the inner bay, where surrounding forests are now dead, whereas juveniles were common in the outer bay, where beetle-kill is still minimal. Adult murrelets were ubiquitous, suggesting that food was available throughout the bay. We recommend murrelet surveys be conducted inland and at sea to monitor possible changes in murrelet breeding distribution.

LONG DIVE OF RHINOCEROS AUKLET IN RELATION TO BODY SIZE

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Diving behavior of alcids are largely unknown. Their diving capacity is assumed to be restricted by the small oxygen storage and the relatively high oxygen consumption rate. Using 20 g time-depth recorder, we recorded diving behavior of eight Rhinoceros Auklets (*Cerorhinca monocerata*) which are the smallest birds that have been studied with this type of device. The dives depth and duration was 15.7 ± 10.2 m (range 1-54.2 m) and 50.1 ± 27.3 sec (range 1-148 sec), respectively. As their calculated ADL (aerobic dive limit) was 59 - 87 seconds, 8.7 - 42.6 percent of their dives exceeded ADL. If the birds exceed their ADL and use anaerobic metabolism, the scattering of dive duration and surface interval should show exponential increase in the surface interval. However the scattering of these birds shows linear increase. Based on these data and compared to other studies, there is some possible explanations about this phenomenon. Firstly oxygen consumption rate of this bird would be lower than that we expected. Secondly this bird would use anaerobic metabolism, but would not exceed its capacity of the ability to clearance of end products or the ability to maintain the pH balance in muscle by the strong buffering capacity.

INDIVIDUALITY OF THICK-BILLED MURRE CALLS

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Individual distinctiveness of calls is strongly needed in animal colonies, since most communication occurs against a background of similar noise. I investigated the individuality of thick-billed murre (*Uria lomvia*) calls at Coats Island, Northwest Territories, to determine if a physical basis for individual recognition was present. There was some individual variation in the calls of even the youngest chicks studied (1 day old). Individuality did not increase with chick age up to 3 weeks, but adult calls were more distinct than chick calls; bird identity accounted for 43.9% of the measured variation in adult calls. Temporal features may be the basis for individual recognition by voice in seabird colonies. They accounted for twice as much individual variation as frequency features, similar to findings for penguin and common murre calls.

DISTRIBUTION OF THE RHINOCEROS AUKLET (*Cerorhinca monocerata*) IN NORTH AMERICA

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Rhinoceros Auklets nest from Bristol Bay, Alaska, and Buldir Island in the western Aleutian Islands, south along the coast of North America to southern California. From the late 1960's to the present, this species has expanded its range south from long established colonies in Washington as far as the Channel Islands near Los Angeles, California. The Farallon Islands were re-occupied in the early 1970's after over 100 years of apparent absence. Rhinoceros Auklets nest in inaccessible caves and cliff crevices along parts of California and Oregon coasts. Nesting occurs almost exclusively in burrows on Castle Island, northern California. In Washington state, Rhinoceros Auklets nest on islands that have deep soil and vegetation such as *Bromus* grasses or shrubs like Salmonberry (*Rubus Spectabilis*). Colonies in British Columbia are forested, although Triangle Island is a grass/forb community. A deep soil layer appears to be an important habitat component in the larger colonies in Alaska.

STATUS OF BRACHYRAMPHUS MURRELETS AT ADAK ISLAND, ALASKA

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Investigations of Marbled and Kittlitz's murrelets in the Aleutian Islands have been limited. We studied their distribution, relative abundance, seasonal trends, and breeding chronology at Adak Island in the central Aleutians from 1993 to 1995. This site is unique in its geographic isolation, its total lack of trees, and its isolation from population impacts including logging and gill net fisheries typical of other regions. We estimated that approximately 800-1,000 murrelets,

predominately Marbled Murrelets, used the island's nearshore waters, primarily during the breeding season. Shore and boat-based surveys described fluctuations in abundance and distribution which were likely related to nesting activity and shifts in prey availability. Detections of Marbled Murrelets on dawn watch surveys first occurred in May, peaked from mid-July to mid-August, and diminished by early September. Detection levels were relatively high (up to 111) when compared to other treeless regions. Murrelets were detected most frequently during the 60 minute period starting 45 minutes prior to sunrise. Approximately 95% of detections were aural and murrelets were rarely seen on dawn watches, indicating they may have used fog as a visual barrier to predators. There were significant increases in the number of detections ($P=0.008$), detection duration ($P=0.027$), and the time of the last detection ($P=0.006$) during late summer.

INFLUENCE OF A SHALLOW OFFSHORE SEAMOUNT ON SEABIRDS

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Seamounts are common topographic features of deep oceans; there may be more than 30,000 seamounts with heights exceeding 1000m in the Pacific Ocean. Seamounts appear to represent dispersal stepping-stones for plants, invertebrates and fish. With few exceptions (Blaber 1986, Bourne 1992, Haney *et al.* 1995) little attention has been focused on the influence of seamounts on seabird distribution. I conducted seabird surveys at Cobb Seamount (46 45'N x 130 48'W) in July 1991 and June 1992. Though 500km from land, Cobb rises from the 2800m abyssal plain to well into the euphotic zone (shallowest point 24m). Detectable responses of phytoplankton, zooplankton and larval fish extended out approximately 1 seamount diameter (~30km). Comparing moving averages, total seabird densities over the summit (± 5 km) were 2.5 and 2.3 times higher in 1991 and 1992, respectively, than off-seamount (25 ± 5 km). Both years, Black-footed Albatross (*Diomedea nigripes*), Fork-tailed Storm-Petrel (*Oceanodroma furcata*) and Leach's Storm-Petrel (*O. leucorhoa*) dominated the seabird assemblage. Compared to off-seamount, average summit densities of Black-footed Albatrosses were 2.6 (1991) and 3.6 (1992) times higher; Fork-tailed Storm-Petrels were 6.9 (1991) and 8.5 (1992) times more abundant; and Leach's Storm-Petrels were 3.1 (1991) and 1.5 (1992) times more numerous. Improved prey availability and/or higher concentrations (primarily larval rockfish *Sebastes spp.*) may explain the observed seabird aggregations.

EFFECTS OF DIET QUALITY ON POST-NATAL GROWTH OF SEABIRDS: CAPTIVE FEEDING TRIALS

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Declines in availability of high quality forage fishes (sand lance, herring, capelin) have apparently contributed to the lack of recovery of some seabirds that were injured by the *Exxon Valdez* oil spill. This study tests the hypothesis that lipid content of the diet is one factor constraining the growth and development of piscivorous seabirds. We raised Black-legged Kittiwake and Tufted Puffin nestlings on controlled diets of either capelin, Pacific sand lance (both high lipid content fishes), or walleye pollock (low lipid content). Both kittiwake and puffin

chicks fed capelin or sand lance had much higher growth rates of body mass and somewhat higher growth rates of wing length than chicks fed the same biomass of pollock. Differences in mass gain between diet groups were more pronounced than differences in wing growth for both seabird species, suggesting that undernourished nestlings will preferentially allocate limited resources to development over mass gain. Puffin chicks converted food biomass to body mass more efficiently than kittiwake chicks. We conclude that when parental provisioning rates are constrained, the lipid content of forage fishes fed to seabird nestlings limits their growth and development.

GENETIC VARIABILITY OF CORY'S SHEARWATER (*Calonectris diomedea*) IN THE N.E. ATLANTIC REVEALED BY DNA FINGERPRINTING

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DNA fingerprinting was used to compare levels of genetic variability within and between eight colonies of Cory's Shearwater (*Calonectris diomedea borealis*) in the Madeira, Azores, Canaries and Berlenga archipelagoes in the northeast Atlantic. Fingerprint diversity, as measured by one probe and two restriction enzymes, showed very little correlation with population size, suggesting that genetic diversity reflects recent history rather than current population size. Mean band sharing between pairs of colonies ($S_{ab}=0.238\pm 0.094$, $n=680$) did not show any relation with geographic distance between colonies, but was significantly lower than the mean band sharing within populations ($S_{xy}=0.277\pm 0.137$, $n=592$) ($t_s=5.932$, 1270 df, $P<0.001$) implying a small degree of population structure across the range of this subspecies. Evidently there is sufficient gene flow between colonies to prevent populations from becoming considerably distinct at these loci ($F'_{st}=0.056$), despite the morphological and behavioural differences known to exist between the sampled colonies of this highly philopatric species.

MARbled MURRELET NEST-FINDING EFFORTS - EFFECTIVENESS OF VARIOUS TECHNIQUES AND THE DISCOVERY OF A NEW TYPE OF NEST

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Over 450 person-days were spent searching for murrelet nests in Big Basin Redwoods State Park, California during the breeding seasons of 1995 and 1996. Four techniques were used: (1) scoping platforms from the ground, (2) searching beneath trees for eggshell fragments, (3) climbing trees in which other evidence suggested nesting, and (4) staking out potentially suitable nest trees at dawn. No evidence of nesting was found in 1995. In 1996, one active nest, one failed nest, and one set of eggshell fragments were found. The paucity of nests found may be due to extensive predation from large numbers of Common Ravens and Steller's Jays; and possibly a reduced nesting effort in 1995. The active nest was monitored by video camera for 12 days until the chick fledged on 21 July. This nest cup was situated against the bole of the nest tree - a 1.7 m

diameter old-growth Coast Redwood. This nest was unique, being the first murrelet nest to be found in an abandoned Western Gray Squirrel nest.

USING INFRARED VIDEO TO PROBE PUFFIN AND AUKLET BURROWS: A "CANDID" CAMERA FOR BURROW-NESTING SEABIRDS

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In 1995 and 1996, field crews at St. Lazaria Island, Alaska, used a small, maneuverable video camera to investigate status and occupancy of Tufted Puffin and Rhinoceros Auklet burrows. Its benefits included: minimized burrow damage which can result from more intrusive techniques of assessing burrow status, less stress to burrow occupants relative to other techniques, and less work for investigators who otherwise would need to excavate a moderate proportion of burrows. The system was designed to be durable and water-resistant. The primary disadvantages of the system were its lack of maneuverability in some burrows (due to roots, rocks or sharp burrow angles) and insensitivity in detecting other burrow occupants (i.e., unattended Storm-Petrel eggs). While commercial versions of the camera are available, this paper describes the system components and costs for those interested in applying the technology to their studies.

MOLT IN COMMON MURRES: A NOVEL SEQUENCE OF FEATHER REPLACEMENT AMONG "WATERBIRDS"

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Ornithological dogma suggests that most diving waterbirds (e.g., loons, grebes, ducks, large alcids) lose all their remiges simultaneously and in random order during their annual flight feather molt. Common Murres do lose all remiges rapidly -- probably within a few days, but they do so in a very ordered way; primaries are dropped first, beginning in the middle of the primaries (P3, P4 or P5) and progressing both inward and outward. In all cases, the outermost primaries are lost before the innermost ones; P2 and then P1 are the last two primaries to be lost. Primary regrowth is rapid and begins nearly simultaneously in all follicles; however, middle primaries are the first to appear, mirroring the sequence in which they were lost. Secondaries drop in seemingly random order when primary replacement is well underway, and appear to regrow simultaneously. Rectrices drop in a variable but non-random order well after secondary replacement is well advanced. Primary molt is completed in approximately 25 days.

EVOLUTIONARY RELATIONSHIPS AMONG THE AUKLETS: A PHYLOGENETIC STUDY BASED ON DNA SEQUENCES

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An understanding of mechanisms of speciation is of paramount importance to evolutionary biology. Phylogenetic reconstruction can reveal the evolutionary relationships among species, from which mechanisms of speciation may be inferred. Molecular markers such as the rapidly evolving mitochondrial genome and non-coding regions of nuclear DNA may be used to produce phylogenetic hypotheses. Despite the large body of data available, evolutionary relationships

among the auklets, a groups of five Northern Hemisphere seabirds (Family: Alcidae), are unclear. To resolve the phylogenetic affinities among the auklets, and to infer the mode of speciation within this group, nucleotide sequences were collected for the mitochondrial ATPase 8 and ATPase 6 genes, and for intron 8 of the nuclear gene for alpha-enolase. Primers were designed for PCR amplification, and ~840 base pairs of the ATPase genes and ~335 bp of the alpha-enolase gene were sequenced. Analysis of single-stranded conformational polymorphisms (SSCPs) of intron 8 of the nuclear alpha-enolase gene indicated that most of the auklet samples analyzed were heterozygous in this region of the genome. Analysis of the sequence data did not resolve the phylogenetic tree for the auklets, a fact that supports the hypothesis that these birds evolved from a single ancestral species within a short time span (rather than as sequential bifurcations). This is consistent with the microvicariance model of speciation (a subset of peripatric speciation). Numerous small populations of an ancestral species may have become peripherally isolated in separate glacial refugia during a past glaciation, and evolved separately due to adaptation to local conditions and random processes such as genetic drift.

TECHNIQUES FOR THE CAPTURE AND RADIO-MARKING OF XANTUS' MURRELETS IN THE SOUTHERN CALIFORNIA BIGHT, 1995-1996

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We captured 459 Xantus' Murrelets (*Synthliboramphus hypoleucus scrippsi*) at sea beside breeding islands (Santa Barbara, Anacapa, and San Clemente islands) in the Southern California Bight during April and May, 1995-1996. Three-person teams worked at night (22:00-04:00 hrs) from inflatable Zodiac boats, using spotlights to assist bird captures with dip nets. Captured birds were delivered to a larger research vessel where another team obtained data and performed procedures prior to release (i.e. measurements, banding, blood samples, radio attachments). Our overall capture rate (4.8 murrelets/hr) was conservative because capture efforts were intermittent through the night. Up to 12 murrelets/hr were captured during peak capture effort and success. We radio-marked 110 murrelets with two different attachment techniques: 1) two non-absorbable sutures with marine epoxy; and 2) stainless-steel subcutaneous anchor and one non-absorbable suture with marine epoxy. We discuss the lifespan of these two attachment techniques and the use of isoflurane (inhaled anesthetic) in a prototype system to improve handling.

ADULT SURVIVAL OF RED-LEGGED KITTIWAKES

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Apparent declines in abundance of the Red-legged Kittiwake combined with poor reproductive performance for the last several years have recently alarmed resource managers. One key to understanding if current levels of productivity are sufficient to maintain population equilibrium is adult survival rates. Since 1988, about 291 breeding, adult Red-legged Kittiwakes have been uniquely banded and resighted in subsequent years at Buldir Island, Aleutian Islands, Alaska as part of a long-term monitoring program. I estimated the mean over-winter survival rate of Red-

legged Kittiwakes using an enumeration method, a Jolly-Seber model (program JOLLY) and SURGE. The adult survival rate was high and in all 3 methods exceeded 0.96. Mean adult life expectancy (depending on the formula used for calculation) is approximately 24+ years, nearly double the estimate for their sympatric congener, the Pacific Black-legged Kittiwake. Although not observed during the course of the study, infrequent, wide-scale stochastic events such as disease or starvation could greatly increase mortality and decrease survival rates. Future plans include continued monitoring of survival rates at Buldir Island, where Red-legged Kittiwake populations have increased since the 1970s for comparison with survival rate data being collected at the Pribilof Islands, where populations have recently declined.

**SEX RATIO IN MARBLED MURRELETS (*Brachyramphus marmoratus*):
APPLICATION OF A NOVEL MOLECULAR SEXING TECHNIQUE, AND
IMPLICATIONS FOR CONSERVATION AND MANAGEMENT**

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In this study, we report data on sex-ratio of Marbled Murrelets for a large sample of birds (n=177) mist netted at Desolation Sound, British Columbia in two years (1994 and 1995). Murrelets are sexually monomorphic and sexes are indistinguishable in the field or in the hand. We describe the application of a novel molecular sexing technique which reliably sexed 100% of birds. Sex ratio was heavily male biased, with 1.98 males: 1 female. Preliminary demographic models for Marbled Murrelets have assumed a 1:1 sex ratio. Our results therefore have important implications for the conservation and management of this species.

CIRCUMPOLAR SEABIRD WORKING GROUP

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The Circumpolar Seabird Working Group was formed in 1993 under the auspices of the Arctic Environmental Protection Strategy, Conservation of Arctic Flora and Fauna. Biologists representing the governments of the United States, Canada, Iceland, Greenland, Norway, Finland, and Russia meet annually. The group functions as an international forum to facilitate and coordinate Arctic seabird conservation, research and management activities. Nine projects are underway. The International Murre Strategy and Action Plan and Eider Strategy and Action Plan will be completed in 1996 and 1997, respectively. The Circumpolar murre banding and monitoring plans will be completed and implemented in 1997. The second issue of the Circumpolar Seabird Bulletin appeared in Fall 1996. The Circumpolar Seabird Colony Catalog database will be implemented in 1997. Disturbance problems at seabird colonies and relevant laws and mitigation measures have been summarized. Summaries of the harvest of seabirds and incidental mortality of seabirds in fishing gear will be completed in 1997.

UTILIZATION OF INFRARED CAMERAS FOR OBSERVATIONAL STUDIES OF ALCIDS AT THE OREGON COAST AQUARIUM

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The Oregon Coast Aquarium recently used infrared camera technology to obtain behavioral data on a nesting pair of Tufted Puffins (*Fratercula cirrhata*). The camera was placed in the pair's burrow the day the chick hatched and ran until the chick fledged. All footage was recorded and archived. For the first three days after hatching, the camera ran 24 hours per day. Footage was then collected randomly.

The infrared camera allowed us to observe many parent-chick interactions such as, brooding and feeding. Parental interactions such as, incubation switches and behaviors in the presence of the chick were also observed. The data on adult-chick interactions during feeding revealed a sequence of interesting events. Our initial hypothesis was that the parents dropped a load of fish on the earthen floor of the burrow and the chick ate on its own. Our observations showed instead that the parent stimulated the chick by bringing fish in and held the fish while the chick pulled on it. This tug-of-war behavior concluded with the parent eventually releasing the fish. This behavior lasted for 15 minutes initially and shortened as the chick aged.

The use of the infrared camera has proved invaluable for recording seabird behaviors. We intend to utilize this technology in the future to capture detailed observations of our breeding Rhinoceros Auklets (*Cerorhinca monocerata*), Pigeon Guillemots (*Cepphus columba*) and the newest member of our collection, the Marbled Murrelet (*Brachyramphus marmoratus*).