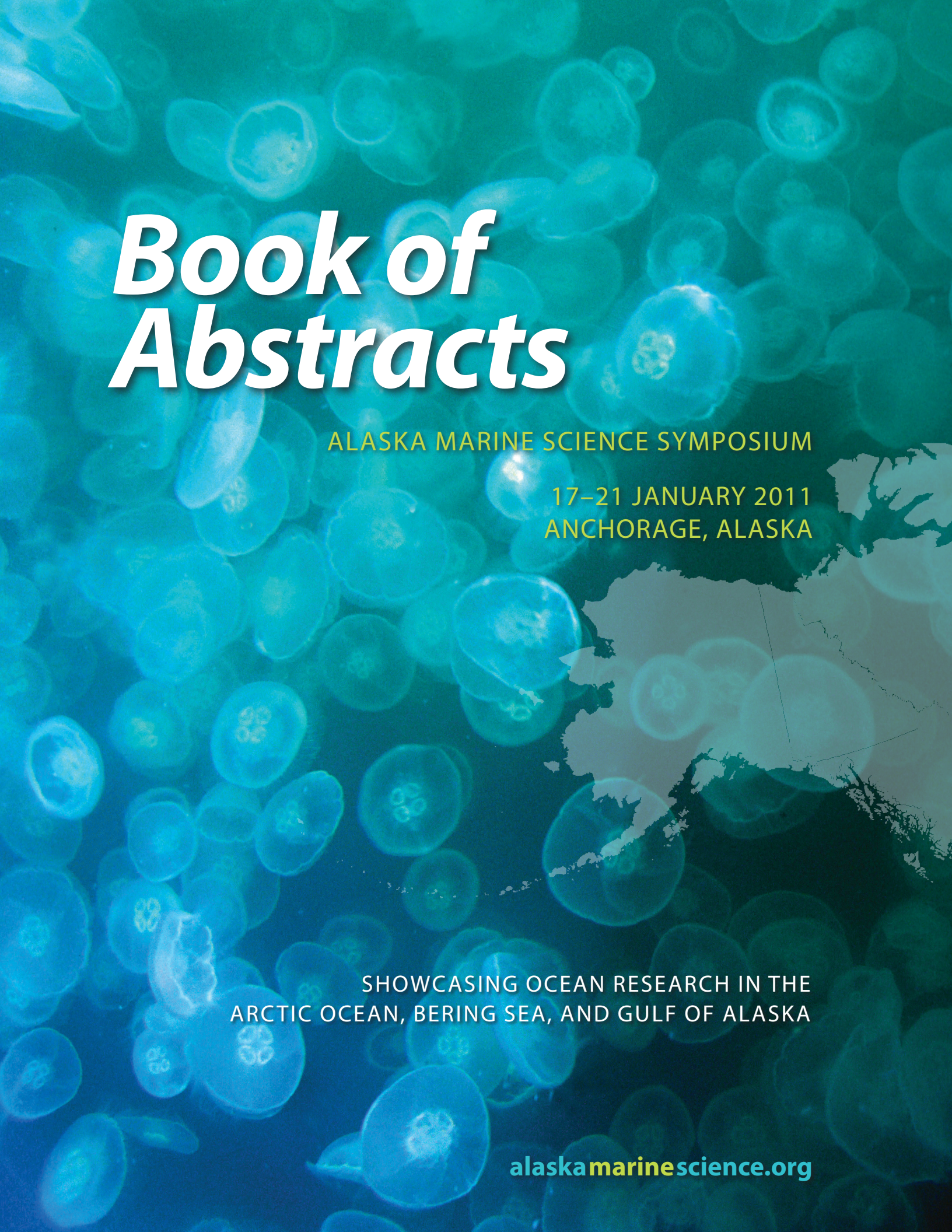

Book of Abstracts

ALASKA MARINE SCIENCE SYMPOSIUM

17–21 JANUARY 2011
ANCHORAGE, ALASKA

SHOWCASING OCEAN RESEARCH IN THE
ARCTIC OCEAN, BERING SEA, AND GULF OF ALASKA

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2011 Alaska Marine Science Symposium Book of Abstracts

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Keynote: Gulf of Alaska

Predator response functions and the "Ecosystem Approach to Fisheries"

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Marine predators such as seabirds and marine mammals feed heavily on small forage species, facilitating rapid transfer of energy to top trophic levels. Because of this, apex predators are useful indicators of the current state of pelagic ecosystems and informative to the "Ecosystem Approach to Fisheries" adopted by many fisheries organizations. Of course, marine birds and mammals are not just handy ecosystem indicators— we also want to maintain healthy wildlife populations and an adequate forage base to sustain them. Whether their primary concern is for fish stocks or for wildlife, managers need quantitative data on the functional relationships between predators and prey to identify "minimum biologically acceptable limits" of forage biomass. We are compiling and contrasting data from several marine ecosystems of the world to assess the form of these basic predator-prey relationships. Preliminary analyses suggest that response functions are usually non-linear and exhibit thresholds. The threshold biomass of prey at sea (bS) required by seabird predators for successful reproduction appears to be 1-3 orders of magnitude greater than the biomass needed to meet metabolic energy demands (bE) of populations during summer. Different predators may have markedly different bS/bE ratios because of differing sensitivities to prey depletion, and sensitivity may be predicted from a few life history characteristics. Our initial findings show promise for discerning what different "indicator species" are actually indicating, and what levels of forage abundance may be required to sustain healthy apex predator communities.

Near-surface circulation in Prince William Sound during the Sound Predictions project

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Oceanographic observations made during the Sound Predictions 2009 field experiment have provided the highest resolution measurements to-date of circulation in Prince William Sound (PWS). The observations included hydrography from CTDs, a glider, and a powered ROV, and dynamical measurements from drifter trajectories and HF radar. In this talk, we will first summarize the observed hydrography and circulation. We will then quantify the relative importance of wind and geostrophy in determining the surface flow, paying special attention to the formation of a re-circulating eddy.

The circulation across all of PWS was cyclonic, with water entering through Hinchinbrook Entrance and leaving through Montague Strait. The strongest currents were found at the surface along the perimeter of the sound. The currents within the central basin, the focal area of Sound Predictions, were weaker. Here, the HF radar and drifters witnessed a change in circulation from an "open" cyclonic pattern to a closed cyclonic eddy. A map of the dynamic height implied the surface flow should form a closed cyclonic eddy. However, this was not observed until late in the experiment, when the drifters began to flow south along the western basin edge. The southward flow was a result of a weakening northward wind-driven flow, and of a strengthening southward geostrophic flow. At the eastern side of the basin, the observed, geostrophic, and wind-driven flows were always directed to the north.

Understanding the conditions under which a closed cell forms is important because a closed configuration would increase the residence time of surface water in Prince William Sound compared to an open pattern.

Speakers: Gulf of Alaska
Ecosystem Perspectives

Recovery of a mussel reef in Prince William Sound 22 years after the Exxon Valdez oil spill and cleanup

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Mussels (*Mytilus trosselus*) are important food resources for nearshore wildlife and their injury following an oil spill could delay wildlife recovery. A "mussel reef," (multilayered mussel bed) on a tombolo on Elanor Island, Prince William Sound, was heavily oiled 1989 but left uncleaned. Annual visits to the site revealed that the mussel bed virtually disappeared as an entity by 1993. Annual monitoring continued over the next 16 years during which time mussels were present at low densities, but scattered across the gravel and not forming a reef structure. Several aerial photos (including by ShoreZone) confirmed the scale of the loss. Sediment and mussel sampling during the first decade following the spill indicated high but decreasing concentrations of oil and Polycyclic Aromatic Hydrocarbons (PAHs). Efforts were made in 1991 to "drain" oil from the gravel underlying the mussel bed, but its decline continued. Elsewhere in Western Prince William Sound (WPWS) we documented two or three "windows" of mussel recruitment during the two decades of monitoring, but not at this site. The inter-annual recruitment periods were similar in frequency to interannual Pacific Decadal Oscillation and El Nino Southern Oscillation (ENSO) indices. In 2007, the beginning of a "cold" regime, there was a heavy "set" of mussels at all sites in WPWS including on the tombolo and on surrounding outcrops. In 2008 multilayer clumps were re-forming on the tombolo and by 2010 there were several large multi-meter-scale areas of gravel overlain by thick layers of 2 to 3 cm mussels.

Thus, the possibility exists that (1) oiled mussel reefs suffer longterm (multi-decadal) delayed recovery following an oil spill and (2) successful recruitment of mussels (leading to short-term periods of high adult densities) only occur aperiodically at intervals driven by, or related to, ocean-scale processes. As with pelagic marine resources (e.g., fisheries), unbroken decadal longterm annual monitoring is critical to understanding variability of shoreline marine life and its ability to recovery to pre-oiling states.

Highlights from 40 years of research in Port Valdez

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Investigations in Port Valdez include multidisciplinary and oceanographic assessments of the ecosystem, investigations of dominant fauna, and long-term environmental monitoring comprising 40 years of research in the fjord. The long-term database (1971 to present) allows for retrospective analysis of intertidal and subtidal data to understand sources of variability within the ecosystem. Highlights of the Port Valdez research are presented. Distributions of intertidal organisms are directly and indirectly affected by the salinity gradient and substrate characteristics and demonstrated large temporal change. Gametogenesis and shell growth of *Mytilus trossulus* occurs in winter when food resources are limited and limpets spawn in late fall with gametogenesis occurring in summer when food resources are higher. Within the deep basin of the fjord, distributions of sediment-dwelling macrofauna reflect recovery from the 1964 Great Alaska earthquake and a strong association with climatic variability (data from 1971-2010). Investigation of macrofauna and polycyclic aromatic hydrocarbons (PAH) at shallower sites (1989-2010) near the Valdez marine oil terminal demonstrate weak associations of PAH (derived from treated ballast-water effluent) with macrofaunal community structure. However, effects were greatest for two tube-dwelling polychaete worms (*Galathowenia oculata* and *Melinna cristata*) that responded negatively to PAH values much lower than the commonly accepted Effects Range-Low criterion. Overall, the biological data indicate an ecosystem in flux from natural variations with human stressors having minor influences. The extensive publication record for the Port Valdez ecosystem provides a basis for understanding long-term variability of benthic communities in coastal Alaska.

Patterns of covariation in prey availability, morphology, behavior and ecology associated with the collapse of sea otter populations in southwest Alaska

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In order to better understand the recent decline of sea otters in southwest Alaska, we assembled data on population density, reproduction, mortality, body condition and health profiles, disease and contaminant exposure, foraging behavior, and food availability from sites across the Pacific Rim, from Prince William Sound in the east to the Commander Islands in the west. We examine these data for consistency with various potential causes of the population collapse. The sea otter decline ranges from Attu Island in the west to about Castle Cape in the east and otter densities are now <1 individuals km^{-1} shoreline through most of this region. There is no evidence for reproductive suppression in the area of decline, indicating that elevated mortality was responsible for both the decline and the failure of the population to recover. Stranded carcasses were found in abundance at sites to the east and west of the area of decline but were rare or absent within this range. Prey abundance, rate of energy gain while feeding, and body condition were higher at sites within the range of the decline than at sites beyond it. Data on blood chemistry, physiological status and measures of disease and contaminant exposure provide no indication that these factors were involved in the decline. From these various analyses, we conclude that food limitation, disease and other density-dependent processes are unlikely explanations for both the sea otter population decline and the failure of the severely depleted population to recover.

Speakers: Gulf of Alaska
Lower Trophic Levels

Abundant, seasonally variable supply of glacier flour-derived iron drives high nitrate consumption in Copper River plume and adjacent Gulf of Alaska continental shelf

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Recent work has suggested that high iron supply may contribute to a northward increase in phytoplankton biomass along the U.S. west coast, consistent with "bottom-up" control of these coastal ecosystems. We examine this hypothesis in waters of the Copper River plume and nearby continental shelf in the northern Gulf of Alaska. High concentrations (several hundred nM) of "total dissolveable" Fe (unfiltered, pH ~2) were present in surface-waters spanning the continental shelf in early April 2010, from resuspension of fine glacial flour. Concentrations decreased dramatically beyond the shelf break. This fine particulate matter represents a large source of "dissolved" Fe to these waters. Surface-water nitrate concentrations were fairly uniform (~15 uM) across the entire shelf at this time, due to deep winter mixing. By late July this shelf particulate Fe source is greatly diminished, owing to strong stratification. Yet there is abundant "total dissolveable" Fe (several uM) at this time from the Copper River plume (largest single freshwater source to the GoA) and lower, significant concentrations in the AK coastal current (that reflect the cumulative impact of melting glaciers from further south). By late July this abundant supply of iron, together with strong stratification, lead to complete consumption of surface-water nitrate across the entire shelf (and extending tens of km beyond the shelf). These data are consistent with the idea that high primary productivity in this region is fueled by abundant wintertime surface-water nitrate, together with iron supply from fine, labile, glacier-derived particulate matter from seasonally variable sources.

Kelp spore susceptibility to sedimentation and light attenuation within Alaska

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Canopy-forming kelps species provide structural complexity for associated communities within Alaska's nearshore. The establishment of kelp spores plays an essential role in kelp distribution and abundance patterns. Environmental variables may control the species-specific dominance that is often observed of kelp in the field. Lab experiments were performed to determine the attachment, survival, and germination rates of the spores of two prominent Alaskan canopy-forming kelps, *Nereocystis luetkeana* and *Eualaria fistulosa*, to 1) various light levels and 2) sediment loads. *Nereocystis luetkeana* and *E. fistulosa* spores had similar attachment success (~30-60%) and germination rates (~70%) under all light levels tested. There was no significant difference between the two species; however, *E. fistulosa* exhibited approximately 2-3 µm longer germ tubes after 48 hours. Spore attachment for both species was significantly affected by suspended particles, settled sediment covering the substratum, and by smothering of settling sediment, decreasing by approximately 90% at the highest sediment load. These results suggest that increases in sedimentation may constrain the success of the microscopic spore stages and thus kelp abundance and distribution within Alaska's nearshore. An understanding of the environmental variables controlling the temporal and spatial establishment of kelp forests in Alaska will help us understand how changes in these variables may affect nearshore communities.

Comparison of three independent methods for estimating red king crab (*Paralithodes camtschaticus*) biomass in southeast Alaska

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One of the main goals of fisheries science is to provide the best stock assessment information to managers. This is an exceedingly difficult task due to the vast areas of fishing grounds and the paucity of fishery independent data. Although biological sampling and population modeling have progressed dramatically, estimating bias and the sensitivity to violating model assumptions remains difficult. The geography of Southeast Alaska provides a unique opportunity to examine these issues due to its relatively small populations that exist in discrete areas surrounded by unsuitable habitat. Here we examine the utility of the ADFG's current biomass methods, improve our understanding of RKC distributions, and foster collaborative effects between the ADFG and the commercial fleet by comparing three independent biomass estimates. Specifically, we compare Catch Survey Analysis (CSA) model with depletion and mark/recapture estimates in four areas. CSA estimates use ADFG summer survey data, while depletion and mark/recapture estimates were done during the Fall on commercial vessels. Data from St. James Bay suggests we can catch and tag 34 – 67% of the total legal population and biomass estimates ranged from 3600 – 8300 legal crab. The depletion estimate was significantly lower than the mark/recapture estimate. There was no evidence for a shift in the distribution of legal sized crab within the area between summer (June) and Fall (November) surveys. However, the changes in the ratio of legal male to mature female crab CPUE suggest large changes in catchability.

Inability to demonstrate horizontal transmission of the highly pathogenic parasite *Ichthyophonus* from laboratory infected Pacific herring (*Clupea pallasii*) to naïve conspecifics

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The parasite *Ichthyophonus* infects several fish species of the NE Pacific, and exhibits high prevalence in Pacific herring (*Clupea pallasii*) populations throughout the region. Published descriptions of *Ichthyophonus* are limited to its existence in fishes, the presumed definitive hosts. The complete life cycle of the parasite is not known and no intermediate/paratenic hosts have been identified. This has led to the hypothesis that *Ichthyophonus* can be maintained in the host population by direct horizontal transmission. To test this hypothesis we established *Ichthyophonus* infections in Age-1 and YOY Pacific herring via intraperitoneal (IP) injection and cohabitated these donors with naïve conspecifics (sentinels) in the laboratory. IP injections established infection in 76 to 89% of donor herring and this exposure led to clinical disease and mortality in the YOY cohort. However after 113 d no infections were established in naïve sentinels. These data do not preclude the possibility of direct horizontal transmission, but they do suggest that it does not happen at a rate that can explain the infection prevalence observed in wild populations of Pacific herring.

Development of tools to forecast the potential for viral hemorrhagic septicemia epizootics in Alaskan herring

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The traditional approach to understanding the impact of disease on populations of wild fishes is based on periodic infection and disease surveys combined with mobilization of epizootiological investigations in response to observed fish kills. This approach, although well-suited for identifying pathogens of concern and providing a list of probable causes for the observed epizootics, is likely to overlook acute disease epizootics that occur non-synchronously with scheduled surveillances or those that occur among highly migratory species that move outside the surveyed area. Further, the traditional approach provides no capacity for preventing, mitigating or predicting the impacts of diseases on the affected populations. We contend that by understanding the disease mechanisms unique to the host-pathogen relationships, we can develop population-screening tools that are capable of forecasting the potential for future disease epizootics. These tools can then be employed to design adaptive management strategies intended to prevent or mitigate population-level impacts of these diseases. Using epizootiological and immunological principles unique to viral hemorrhagic septicemia (VHS) in Pacific herring, we describe the development of several tools (an in vitro fin explant assay, a passive immunization assay, and an Enzyme-Linked-Immunosorbent Assay (ELISA) to detect herring antibodies against VHSV) that may be capable of forecasting the potential for future VHS epizootics in populations of Pacific herring throughout Alaska.

Importance of prey quality to North Pacific marine fish larvae: a test case with Pacific cod (*Gadus macrocephalus*)

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Changing environmental conditions in the North Pacific are altering the lipid/fatty acid composition of zooplankton assemblages, but the consequences to resident fish larvae are unknown. In the laboratory, we reared Pacific cod larvae over a 4-wk period on live-prey enriched with varying levels of two essential fatty acids, docosahexaenoic acid (DHA, 22:6n-3) and eicosapentanoic acid (EPA, 20:5n-3), to determine how this species might respond to such changes in prey quality. Ratios of DHA:EPA were chosen to represent the natural variation observed in zooplankton of the North Pacific. We tested two hypotheses: 1) whether energetically similar diets comprised of varying levels of EPA and DHA impact growth and survival in cod larvae, and 2) whether the highest levels of DHA:EPA (2:1) are optimal for Pacific cod larvae, as it has been shown for Atlantic species. Results indicated that Pacific cod larvae grew fastest with diets containing elevated n-3 PUFA (>22%). Diets with the same total lipid content but different ratios of DHA:EPA (<0.1:1 to 2:1) also mediated growth and lipid composition of the larvae. Interestingly, unlike Atlantic cod, Pacific cod larvae did not show as high a requirement for DHA relative to EPA but rather achieved largest size-at-age with intermediate DHA:EPA ratios ranging from of 0.8:1 to 1.1:1. This range most closely resembled average levels of DHA:EPA reported from copepods of the North Pacific, suggesting anomalous years with an over- or under-abundance of DHA-rich dinoflagellates or EPA-rich diatoms may be detrimental to growth of Pacific cod larvae in the field.

The hatchery regime shift

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In Alaska, salmon management, since the low returns in the 1950s, 1960s, and 1970s, has incorporated two main features – an effort to rebuild and manage for escapements and, in some parts of the state, an industrial-scale ocean ranching hatchery program. The theory behind escapement-based management is well supported by ecological observations that it takes fish to make fish and that there are carrying capacity limits on production. The hypothesis behind the ocean ranching hatchery program is less clear but it must be that the ocean has an untapped rearing potential and that if you release more fish you'll get more back. With hatchery releases high and increasing, and stocks of co-rearing salmon, herring, and eulachon decreasing, we might just be using hatcheries to rebuild wild runs until they are gone. Using stock-recruit and release-return data I show that hatchery releases have invoked a "regime shift" lowering of wild stock productivity in some areas and advise marine researchers to consider the ecological consequences of ocean ranching in their stock assessments.

Estimating distribution and abundance of rockfishes using a combination of acoustical, optical, and trawl survey tools

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Rockfishes are difficult to assess using standard acoustic and bottom trawl surveys due to their propensity to aggregate in rocky high-relief (untrawlable) areas. An experimental acoustic survey consisting of eight large-scale survey passes of an area and multiple fine-scale surveys where fish were concentrated was conducted aboard the NOAA research vessel Oscar Dyson and a commercial fishing vessel in 2009. Acoustic data were collected with Simrad EK60 scientific echosounders operating at 5 frequencies and a Simrad ME70 multibeam sounder. A remote operated vehicle (ROV), a stereo drop camera, and a modified bottom trawl were used to groundtruth acoustic targets. More than half of the study area was characterized as untrawlable using the ME70 seafloor data. Camera tows indicated pelagic rockfish species were dusky rockfish (69%) and northern rockfish (20%). These species also occurred on the seafloor with a mix of juvenile Pacific ocean perch, harlequin rockfish, and unidentified rockfish. The species and size compositions were similar among the trawl, ROV and stereo drop camera, but different between trawlable and untrawlable areas. Acoustic data indicated that the biomass of fish in the water column was not significantly different between passes or diel periods and that rockfish occurred pelagically in both trawlable and untrawlable habitats in the study area. Most of the observed fish sign occurred near the seafloor (< 5 m off bottom) which indicates that estimating the proportion of fish within the near-bottom-zone where they are not detected by the echosounder (~< 1 m) is critical to estimating fish biomass.

Application of the POST Prince William Sound Acoustic Array to assess movements and dispersal of lingcod

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The Pacific Ocean Shelf Tracking (POST) Project tracks movements of tagged marine animals from California to Alaska using a series of acoustic receiver lines. In October 2008 we deployed a POST array across the mouth of Port Gravina in Prince William Sound. We also deployed 7 receivers on a series of pinnacles north of the POST array. Here we report on movements by tagged lingcod (*Ophiodon elongatus*) monitored for up to 20 months. We documented long maximum residency periods, limited movement between pinnacles, and a relatively small number of temporary absences. Movements out of Port Gravina followed by a return to the capture site were rare, and observed only for adult female lingcod. Our research demonstrated that acoustic arrays can be an effective means of obtaining precise information on the timing and direction of lingcod dispersal. Thirteen of 16 lingcod (87%) initially aged at 2.5 to 3.5 years-old dispersed from their tag site including 10 that migrated out of Port Gravina. Only one adult, a 950 mm male, migrated out of the bay. Dispersal movements tended to be southerly and relatively rapid with most fish detected at multiple receivers over a <24h period before disappearing. Except for the adult male, dispersal was highly seasonal and occurred during two periods, mid-December through January and mid-April through May. Dispersal in winter may be related to sexually immature or newly-mature lingcod being displaced by territorial males. Spring dispersal may be indicative of the onset of migratory behavior where lingcod move out into Prince William Sound and possibly the offshore waters of the Gulf of Alaska. The POST array of autonomous hydrophones revealed important aspects of movement and behavior of lingcod in Prince William Sound and, more broadly, demonstrates the efficacy of maintaining a fixed array of hydrophones.

Tracking tagged fish with an autonomous underwater vehicle

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Autonomous underwater vehicles (AUVs) are increasingly being used to collect information in the marine environment. Recent efforts have been made to merge AUV technology with acoustic telemetry to provide information on the distribution and movements of marine species. We conducted a study in coastal waters near Juneau, Alaska to determine the feasibility of using AUVs to locate marine species in complex environments compare to traditional vessel-based tracking. Tracking surveys were conducted with an AUV equipped with an integrated acoustic receiver and hydrophone. The AUV was programmed to navigate along predetermined routes to detect and record acoustic transmitters within the area. Comparable surveys were conducted with a boat equipped with acoustic tracking gear. Moorings with transmitters provided acoustic targets at known locations and depths. Marine animals, principally sablefish and king crab, were acoustically tagged to supplement the sample. Transmitter depth had a major impact on tracking success. Boat surveys were more effective detecting transmitters at shallow depths, while the AUV had greater success at moderate and deep depths. The AUV had difficulty navigating due to strong currents and extreme depths which limited sensor contact with the ocean floor. AUVs with greater cruising speeds, increased operating depths, and improved internal navigation would enhance AUV operations in coastal Alaska. AUV technology has enormous potential to monitor fish populations and to address research and management issues in the northern Pacific. AUV sensors provide proximal information on surrounding conditions, making is possible to integrate fish telemetry data with geomorphic and environmental data.

Characterizing space use of Pacific halibut during summer in Glacier Bay, Alaska using acoustic telemetry

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A fine-scale acoustic telemetry project on the movement of Pacific halibut was conducted in Glacier Bay, Alaska, from 1991 to 1993. Tagged halibut were located daily to weekly using vessel-based tracking during tracking periods ranging from 4-6 months each year. This work provided the first information on the scale of space use for Pacific halibut during summer, where tagged fish demonstrated both constrained and dispersive movement patterns. We will present an update on the analysis of the telemetry data that incorporates recent advances in analysis methods and information from a habitat map of the study area that was produced in 2006. By combining information on tagged halibut locations with bathymetry and habitat information, we are able to generate hypotheses about mechanisms that underlie observed patterns in space use for halibut in Glacier Bay.

Field studies in support of the stock assessment of the giant Pacific octopus, *Enteroctopus dofleini*

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Research is currently underway in Alaska waters to examine the life history of *Enteroctopus dofleini* and to develop field techniques to support stock assessment of the octopus species assemblage. *E. dofleini* specimens for this study were obtained during the months of February, May, and October 2010. A total of 75 samples (36 female, 39 male) were obtained ranging in size from 1.2 to 22.3 kg. A gonadosomatic index (GSI) was calculated, the condition of the reproductive tract was examined, and a gonad maturity coding system was developed for male and female *E. dofleini*. Preliminary reproductive study results do not indicate strong seasonality in the reproductive cycle with mature males and females observed within each sampling period. Visual inspection, GSI, and histological results indicate both male and female *E. dofleini* mature around 10-12 kg. The initial study also included a vessel charter for testing and developing 'habitat pots'; a specialized gear designed for scientific studies and possible future index surveys of octopus abundance. A variety of pot designs and materials are being tested for use in Alaska. The initial data indicate that longlined plywood box pots are an economical and feasible method for capturing octopus. In the spring trials, plywood box pots and scrap ATV tires had a capture rate of about 30%, but pots made from a variety of plastic materials had a much lower catch rate (<5%). Results from this research will be incorporated into future stock assessments for the octopus species assemblage.

Why aren't pigeon guillemots in Prince William Sound, Alaska recovering from the Exxon Valdez oil spill?

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The Pigeon Guillemot (*Cepphus columba*) is the only avian species in Prince William Sound (PWS), Alaska known to have been damaged by the Exxon Valdez oil spill (EVOS) that has failed to show signs of population recovery. Although there is no longer evidence that guillemots are exposed to residual oil from EVOS, the population has declined by more than 85% from ca. 15,500 individuals in the 1970's to ca. 2,100 in 2007. We investigated potential factors currently limiting recovery at the Naked Island group, which formerly supported one third of the Sound-wide population of guillemots. Specifically, we addressed (1) availability of schooling forage fish and (2) nest predation. The overall abundance of schooling forage fish in central PWS has increased since the 1990s, suggesting that forage fish populations are recovering from EVOS. The weight of evidence strongly suggests that population recovery of guillemots nesting at the Naked Island group is now limited primarily by American mink (*Neovison vison*) predation. Comparison of guillemot population trends at the Naked Island group to elsewhere in PWS provides additional support for the mink predation hypothesis. Genetic analysis indicates that mink on the Naked Island group are descended, at least in part, from fur farm stock and available evidence suggests that mink were introduced to the Naked Island group by humans within the last 30 years. Eliminating mink predation on guillemot nests and adults would likely result in a dramatic increase in the nesting success and population size of guillemots at the Naked Island group.

Speakers: Gulf of Alaska
Mammals

Ecologically meaningful units for managing harbor seals

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Harbor seals (*Phoca vitulina richardii*) are one of the most commonly encountered marine mammals in Alaska, occupying a broad range along the state's southern and western coasts. Monitoring and management of harbor seals in Alaska has been based on a division into three large units, a division that is inconsistent with local variations in population trends. While numbers declined at Tugidak Island, Prince William Sound, Glacier Bay and the Aleutian Islands, many adjacent populations remained stable or increased. Moreover, based on analysis of genetic data, harbor seals in Alaska are thought to comprise several, relatively discrete breeding populations. For these reasons, the National Marine Fisheries Service worked closely with its co-management partner, the Alaska Native Harbor Seal Commission, to develop boundaries for 12 new management stocks. Aerial surveys obtained annually in large portions of the statewide range during 1998-2007, formed the basis for estimates of the abundance and trend of harbor seals in each of the 12 management stocks. The total statewide abundance estimate, including adjustments for survey conditions and seals not detected, is 152,602, with the largest stocks represented by Prince William Sound, Clarence Strait and Cook Inlet/Shelikof regions. Tracking the populations in these new, more ecologically meaningful units will enable more effective detection of and response to conservation risks.

Temporal and spatial variation in age-specific survival rates of Steller sea lions from Southeast Alaska

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We estimated age-specific survival probabilities for a threatened population of Steller sea lions (*Eumetopias jubatus*) in Southeast Alaska, using mark-recapture models, data from 1,995 pups and resightings from Oregon to the Bering Sea. Survival of females averaged 0.64 , 0.77 and 0.91-0.96 at 1, 2 and 3+ yrs. Compared to females, survival of males was reduced by -0.04 to -0.08 per age, resulting in nearly twice as many females as males alive at age 7 yrs. Temporal effects included cohort effects on survival from 0-2 yrs, with maximum cohort differences of 0.18. Spatial variation was observed (1) as ~2-3 times more pups from northern rookeries (including an area of rapid growth in Glacier Bay and Icy Straits) surviving to 7 yrs as pups from southern rookeries (including a high density and stable rookery at Forrester Islands); and (2) as enhanced survival to age 7 yrs (+0.07) for non-pups that used northern Southeast, regardless of birth rookery. A survival cost for long-distance dispersal for males was suggested by a -0.13 reduction in survival for males that traveled outside Southeast and British Columbia. Larger body mass at 2-4 wks of age also improved future survival. Sea lion population dynamics may be sensitive to cohort effects with the compounding effects of conditions in the birth year and body size when <1 month of age. Movements to more productive, safer, or less dense areas may alleviate a poor start and provide a mechanism for source-sink spatial structure for sea lion populations.

Remotely-delivered chemical immobilization of adult female Steller sea lions for physiological sampling and satellite telemetry attachment in Southeast Alaska

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Understanding foraging behavior and body condition of adult female Steller sea lions is a critical data need, but also the most difficult to obtain due to the high risk of capture mortality. During 2-7 November 2010 we immobilized six adult female Steller sea lions observed with pups in Lynn Canal and Frederick Sound, Alaska using a combination of medetomidine-butorphanol-midazolam (dosage range approximately 0.038-0.044, 0.13-0.15, and 0.19-0.22 mg/kg respectively) via remotely delivered darts at distances of approximately 12-20 meters. Three animals were approached approximately 12 minutes after darting and were found on the haul-out at a deep plane of anesthesia, allowing for intubation, branding, satellite-telemeter attachment and collection of morphometrics, blood, blubber and whisker samples to assess health status and diet. Animals were supplemented with isoflurane (range 0.5-1.5%) in 100% oxygen to maintain anesthesia for ≤130 minutes. Heart rate, respiratory rate, body temperature, oxygen saturation and blood gases were monitored throughout the procedure. Physiological parameters were within expected ranges except blood glucose, which was elevated and increased over time. Animals were reversed with naltrexone (30 mg) and atipamezole (45 mg) via intramuscular injection. Animals were mobile and alert 9-12 minutes after injection of reversal agents, and post-handling foraging behaviors were monitored using Mk10 Argos Fast-GPS transmitters. Three darted animals entered the water after injection and were followed for up to 145 minutes to verify survival. This preliminary study resulted in successful capture of adult animals on haul-outs. Equally important we demonstrated that animals entering the water after darting survived.

Speakers: Gulf of Alaska
Mammals

Examining the structuring of killer whale populations across the northern North Pacific

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Killer whales (*Orcinus orca*) throughout the North Pacific Ocean can be broadly classified into three distinct ecotypes (residents, transients and offshores) that occur in sympatry, yet segregate according to their ecological niche, behavioral and acoustic patterns, and phylogenetic lineage. As apex predators in high latitude waters, killer whales interact with commercial fisheries both directly and indirectly. The management and conservation implications of such interactions necessitate an understanding of the size and structure of killer whale stocks within these productive waters. In this study, we use molecular genetic data alongside photo-identification data to examine the structuring of killer whale stocks in the northern North Pacific. A total of 483 skin biopsies, representing all three ecotypes, were collected from killer whales during shipboard research surveys between 2000 and 2010, from the Gulf of Alaska to the Sea of Okhotsk. Mitochondrial control region sequences (980bp) and multi-locus nuclear microsatellite genotypes (27 loci) were generated for each sample and duplicate samples were identified by direct comparison of both genotypic and photographic identification data. Complementary phylogenetic and genetic clustering algorithms were employed to explore population structuring. Broad-scale analyses support previously described ecotypic subdivisions, and genetic clustering of samples within the "resident" and "transient" ecotypes indicate varying levels of population structuring and gene flow. Geographic patterns of genetic differentiation suggest a significant degree of structuring within the "resident" killer whale population. Conversely, higher levels of gene flow can be ascribed to the "transient" killer whale population, characterized by genetic clusters that are not strictly geographically based.

Seasonal Distribution of Cook Inlet Beluga Whales Based on Passive Acoustic Monitoring

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The current seasonal distribution of Cook Inlet beluga whales (CIB) is essentially unknown. The summer distribution of CIB has been estimated through aerial surveys, whereas limited information from CIB satellite tagged ~10 years ago indicates an over-winter distribution in the upper inlet. New information on the seasonal presence of CIB throughout Cook Inlet has been obtained using passive acoustic monitoring. Mooring packages containing Ecological Acoustic Recorders (EARs) and echolocation click detectors (C-PODs) deployed at 10 sites continuously monitor the presence of CIB. Based on preliminary analyses, CIB have been detected at sites in the upper and mid-inlet, and their presence does not appear consistent across months. CIB were not detected at the two most southern sites, Tuxedni Bay and Homer Spit. Noise from water flow, shipping traffic, and industrial activities varied among locations and often made call detection challenging due to masking. Detection of calls was surprisingly low at Cairn Point, considering CIB must pass this site in transit to, and from, Knik Arm. Cairn Point is the noisiest of the monitored locations due to heavy industrial activity, so more masking may occur there; alternatively, belugas may suppress calling while in this area. Belugas were detected in the upper inlet during the winter freeze, yet their range may extend further south than in summer. Signals produced by killer whales, tentatively identified as residents, were detected mostly in the lower inlet but were detected further north in the fall, and harbor porpoise were detected throughout the inlet.

Inshore and offshore movement of humpback whales in the Gulf of Alaska: Are offshore whales different from their coastal neighbors?

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Humpback whales have been studied in the coastal waters of the Gulf of Alaska (GOA) since the late 1960s but information about whales foraging offshore is limited. In 2004, a large-scale collaboration, Structure of Populations, Levels of Abundance and Status of Humpbacks (SPLASH), provided opportunities to study humpback whales in both inshore and offshore habitats. Using identification photographs and biopsy samples, we explored individual movements, the distribution of mitochondrial (mtDNA) haplotypes and trophic levels for humpback whales within three regions (Kodiak (KOD), Prince William Sound (PWS) and southeastern Alaska (SEAK) of the GOA to determine if inshore and offshore aggregations of humpback whales are distinct. Each region was divided into inshore and offshore habitats, creating six subareas for comparison. Movements of 2,136 individual whales were most frequent between inshore and offshore subareas within a region, with minimal movement between regions. Tissue samples of 485 humpback whales included 15 mtDNA haplotypes. Pair-wise $\chi 2$ tests showed haplotype differences between subareas, but inshore PWS was the only subarea with a haplotype composition significantly different than all other subareas. Trophic levels, as inferred from stable nitrogen isotope ratios, were significantly different among subareas (ANOVA; $F_{5,414} = 59.3$, $p<0.001$), ranging from 3.4 to 4.5. Pair-wise comparisons showed that inshore PWS was, again, the only subarea that was significantly different than all others. Therefore the combined inshore and offshore habitats for KOD and SEAK should each be considered as single regional feeding aggregations, while inshore PWS may represent a separate aggregation from PWS offshore.

Cruise ship-humpback whale interactions in Alaska

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Cruise tourism in Alaska continues to be a contentious issue with conflicts arising over the appropriate level of regulation and taxation stemming from potential impacts on water and air quality, visitor experience, community economics, and cultural resources. Cruise ships may also affect marine mammals via acoustic disturbance and/or collisions as demonstrated by several highly publicized mortalities as a result of collisions between cruise ships and whales in 2010. To better understand the frequency and severity of interactions between ships and whales in Alaska, observers have been placed aboard cruise ships for the past four years. From 389 cruise-days accounting for over 2700 hours of effort, observers recorded over 1600 unique encounters between ships and humpback whales. Over 25% of encounters were within 300m, and a number of 'near misses' were recorded, i.e., the whale passed within 100m of the bulbous bow. Encounters were spatially and seasonally aggregated near the mouth of Glacier Bay and near Pt. Adolphus. More importantly, ship speed strongly influenced encounter distances. Using a Bayesian change-point model, an inflection was found in the relationship between encounter distance and ship speed: average encounter distances when ships were going slower than 12 knots was nearly 30% larger, providing more time for evasive measures by whales and or ships, compared to average encounter distances when ships were faster than 12 knots. These results were then modeled relative to recent abundance estimates of humpback whales in Southeast Alaska to ascertain the impacts to the population under different levels of cruise ship traffic.

Keynote: Arctic

Oil Spill Commission Report and the Implication for Future Offshore Oil Development

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President Barack Obama established the BP Deepwater Horizon Oil Spill and Offshore Drilling Commission to investigate and document the causes of the spill and make recommendations to prevent future spills from offshore drilling. University of Alaska Anchorage Chancellor Fran Ulmer was appointed to the commission along with six others.

Since July 2010 Oil Spill Commission members have made site visits in all the Gulf states, held public meetings in New Orleans and Washington, D.C., and heard testimony from industry and government representatives and many others. They've received extensive background information describing the factors that contributed to the April 20 explosion that killed 11 workers, and led to an estimated 200 million gallon oil spill requiring the largest environmental cleanup in U.S. history.

On January 11, 2011, commissioners will present their final report to President Obama. Recommendations for improving process safety systems, creating higher standards for safe operation and a better-resourced and better-prepared regulator are among the recommendations which will have implications for future offshore oil development in the Gulf of Mexico, in Alaska and elsewhere.

Year-to-year variability of ocean conditions across Barrow Canyon and the western Beaufort shelf: 2005-2010

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Interannual variability in biological and physical ocean conditions on the shelf near Barrow, AK has been documented from 2005-2010 as part of an ongoing study. Multiple water masses were observed each year, with close coupling between water mass and biological characteristics. Three years (2005, 2007, and 2010) were characterized by little or no sea ice and warm surface and Pacific-origin water (~11°C in 2007), while a reduced amount of Pacific Water in 2006, 2008, and 2009, and melting sea ice in 2006, contributed to colder surface waters (<4°C). Short-term variability in conditions on the shelf, including plankton abundance and composition, was intimately tied to the direction and strength of the wind. Interannual variability in biological conditions on the shelf including dramatic changes in the zooplankton community abundance and composition, a correlation between the presence of coccoid cyanobacteria and Pacific Water, and a dramatic increase in the abundance of euphausiids in 2009 that may be related to larger scale physical or biological influences, such as increased transport of euphausiids to the region from the Bering Sea.

Surface Current Measurements in the Northeast Chukchi Sea Using Shore-Based High-Frequency Radar

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Hourly surface currents were measured from the shore of Barrow and Wainwright, Alaska, from mid-September through mid-November 2009 and from mid-July through freeze-up 2010, using High-Frequency Radar. Data collected has six kilometer spatial resolution, extends up to 200 km offshore, and is representative of the top two meters of the water column. Preliminary results have yielded numerous circulation features, including an intermittent, a strong coastal current approximately 30 km in width with speeds in excess of 50 cm/s. Frequent mesoscale eddy variability was observed on time scales of less than a day. Eddies were commonly located near the head of Barrow Canyon and southeast of Hanna Shoal and were approximately 30 – 40 km in diameter.

Average currents for the 2009 fall deployment period were generally westward at 6.1 cm/s, under mean winds from the northeast at 5.9 m/s; however, south of 71.25 N there was more variability in the mean current direction and magnitude. Principal axes of variance are alongshore within the coastal current and oriented east/west farther offshore. Variance nearshore is a factor of five greater than the offshore variance. The cross-shore correlation length scale of the alongshore velocity is ~40 km, consistent with the width of the coastal current.

A third field site was installed in Point Lay, Alaska, in mid-September 2010, in order to extend coverage to the south, and all three systems will again be operational beginning in July 2011. Current maps may be viewed in real-time at www.chukchicurrents.com.

AUV glider missions in the Northeast Chukchi Sea

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Here we report on Autonomous Underwater Vehicle (AUV) missions in the Chukchi Sea during summer 2010. Hydrographic data was collected using two Webb Slocum gliders deployed from the 32' vessel Tukpuk operating off Wainwright. Gliders are low-power high-endurance AUVs propelled by small buoyancy changes, making the AUV slightly more (less) buoyant than ambient water, generating forward motion by gliding on wings attached to the body towards the surface (bottom). The gliders performed two month-long missions from mid-July to mid-August and mid-September to mid-October collecting data continuously at 1 Hz. A total of 70 days of AUV missions resulted in over >800 km of track length covered, collecting >3500 vertical profiles of pressure, temperature and conductivity (salinity) along with estimated depth-average currents. The month-long missions represent the first successful long-term AUV missions in this area.

The detailed data from the gliders gives a unique view of the Chukchi Sea, with <150 m horizontal resolution and sub-meter vertical resolution. We were able steer the gliders from offshore of Wainwright to both the Burger and Klondike hydrocarbon lease patches while operating under the HF Radar surface data mask, providing a detailed 3D spatial and temporal view of the ocean. We present preliminary high-resolution cross-sections, time-average properties and oceanic response to frequent storms.

The glider surveys show that using AUVs can be a cost effective ways to observe remote areas and generate uniquely high-resolution data; both gliders will be deployed again in 2011. Lastly, we present some novel ways to use gliders in the Arctic for biochemical and marine mammal studies.

The Barents and Chukchi Seas Compared: Why is the Barents so much more productive?

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Although both the Barents Sea and the Chukchi Sea are at similarly high latitudes, are seasonally covered in sea ice and have strongly advective regimes, these two Arctic marginal seas differ remarkably in the species diversity and biomass of top predators, including fish, seabirds and marine mammals, all of which are much more abundant in the Barents Sea than in the Chukchi. Both seas receive water from the south, but the water entering the Barents Sea comes from the deep, ice-free and relatively warm Norwegian Sea, and contains not only nutrients, but also a rich supply of phytoplankton and zooplankton that are available to support larval fish in spring. This water travels eastward in the southern Barents, creating a relatively warm and ice-free habitat when compared to the northern Barents or the Chukchi. In contrast, the water entering the Chukchi Sea in spring is cold, having traversed the shallow Chirikov Basin in the northern Bering Sea, which is ice covered in winter, and possibly depleted of zooplankton, many of which need deeper water for over wintering. This water moves northward through the Chukchi into the Arctic Basin. It is telling that planktivorous seabirds nest primarily to the south of Bering Strait, whereas in the Barents Sea, planktivorous seabirds are abundant nesters on the shores of Svalbard. It is possible that the timing of the arrival of abundant zooplankton in the Chukchi is too late to support a high biomass of fish; the ice-utilizing arctic cod (*Boreogadus saida*) being the primary fish present. Benthic habitats are particularly rich in the southern Chukchi when compared to either the northern Chukchi or the Barents Seas. Marine mammals are more abundant and have a higher diversity of species present in the Barents than in the Chukchi. In the Chukchi, climate warming is unlikely to significantly change the availability of zooplankton in spring, as the seasonal ice cover for the northern Bering and Chirikov Basin is expected to persist long into the future. In contrast, changes in the advective regime of the Barents are possible with changing climate, and such changes could have a marked effect on the productivity of the Barents Sea and its ability to support large populations of fish, marine mammals and seabirds.

Arctic Ocean Diversity (ArcOD) Synthesis: How many species are there?

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One of ArcOD's mission as part of the Census of Marine Life was to complete the first pan-Arctic inventory of biodiversity in the Arctic's three major realms: sea ice, water column and seafloor – from the shallow shelves to the deep basins. The current inventory, based on compilation of historic and recent data and on new field collections, demonstrates highest diversity in the smallest size classes with: 4500 OTUs (operational taxonomic units) of archaea (estimate), 45,000 OTUs of bacteria (estimate), close to 2000 single-celled eukaryote phytoplankton species, >1000 single-celled eukaryote ice-associated species, ~60 ice-associated metazoans, 350 zooplankton species (with nearly half of them occurring only in deep water), nealy 200 macrophytic algae, close to 3000 benthic shelf macro- and megafaunal species, more than 1000 benthic deep-sea species (including meiofauna), 240 fish species, at least 64 breeding seabird species, and 16 marine mammal species. More than 70 undescribed species were discovered during field expeditions. For the invertebrates, species inventories appear to be relatively complete for zooplankton, but not for benthos. Within the metazoan fauna, crustaceans dominate species richness in all three realms while diatoms dominate ice algal and phytoplankton richness. There appears to be no zoogeographical barrier between the Eurasian and Amerasian basins in all three realms. Distinct zooplankton communities exist for different depth zones with high within-depth similarity. For benthic communities, regional differences appear to be larger on the shelves than in the deep sea. A mid-depth (500-2000 m) peak in species richness was found for zooplankton, but not for benthic taxa. Recent changes in diversity include range extensions, changed ratios of warm-water to cold-water species, species replacements, and changes in species densities: most are probably related to climate change.

In Search of Sources and Distribution Patterns for Trace Metals in Seawater, Biota and Sediments of the Eastern Chukchi Sea

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During the COMIDA Project, metals are being used as tracers of natural processes and as indicators of possible impacts from human activities. The evolving data set has advanced our search for sources and patterns for dissolved and particulate metals in the water column and has helped explain the spatial distribution of metals in bottom sediments. Concentrations of most dissolved metals have been relatively uniform in the study area, for example, 47 ± 13 ng/L for Cd and 334 ± 60 ng/L for Ni. Despite this overall uniformity, concentrations of some dissolved metals, such as Cu, were significantly higher in the Alaska Coastal Current than found farther offshore. Concentrations of total suspended solids averaged 0.39 and 1.6 mg/L above and below the pycnocline, respectively. Particles from the upper water column had a higher content of trace metals and organic carbon with only a minor fraction from resuspended bottom sediments. The northern Neptune whelk (*Neptunea heros*) is being used as one indicator organism for metals. Relatively uniform concentrations were found for Zn (72 ± 4 µg/g) and most metals in the whelk; however, results for As, Pb and Cd showed 2 to 10 times greater values at two southeastern locations. Metals in bottom sediments were at background concentrations with predictable ratios to Al, except for instances of As, Ba and Se enrichment in surface sediments due to natural diagenetic processes and higher Ba values near two 1980s exploratory drill sites where traces of drilling mud and cuttings were found.

COMIDA: Sources and Fates of Nitrogen and Carbon in the Benthic Ecosystem of the Eastern Chukchi Sea

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The Chukchi Sea Offshore Monitoring in Drilling Area (COMIDA) Project is a comprehensive program funded by the Bureau of Ocean Energy Management, Regulation and Enforcement (BOEMRE) designed to establish an integrated knowledge of this biologically productive and diverse ecosystem. This component addressed benthic community structure, the food web dynamics on the inner shelf of the Chukchi Sea, and inorganic-N cycling based on mid-summer field measurements. Throughout the study area, infaunal abundance values were dominated by polychaetes (50%), bivalves (25%) and crustaceans (20%) while biomass was highest in the bivalve group (50%) followed by sipunculids (20%) and polychaetes (18%). Stable isotopic analyses show that the benthic community clearly relies on multiple carbon sources, and certain organisms show fidelity to specific food sources. Benthic microalgal communities appear to be an important but overlooked source of carbon to lower trophic organisms as reflected in relatively heavy values (e.g. δ13C ~ -19‰). Concentrations of porewater ammonium, a possible source of inorganic-N to the microphytobenthos, ranged from 111-348 µM in summer 2009 and 48-233 µM in 2010. These values likely reflect rates of sediment oxygen consumption that ranged from ~150 to 400 µmoles m-2 h-1. Calculated fluxes of nitrate, based on incubations of intact sediment cores, also revealed that Chukchi Sea sediments are a source of nitrate. These data suggest that the biogeochemical exchanges occurring across the sediment-water interface are critically important to the overall productivity and diversity of the benthos.

COMIDA: Pelagic-Benthic Coupling and Benthic Community Structure in the Chukchi Sea

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Over fifty shipboard stations were occupied in 2009 and 2010 as part of the COMIDA CAB program to evaluate benthic biological systems in the Lease 193 oil and gas development area in the Chukchi Sea. Sampling used both van Veen grabs and a Haps sediment corer for both community characterization and sediment community oxygen consumption measurements. Macrofaunal abundance was highest in troughs between the Alaska coast and offshore shoals (>10,000 individuals (ind)/m2) compared to shallow nearshore and offshore shoals (<1000 ind/m2). However, benthic biomass was more variable, ranging from 10 to >1000 g wet wt/m2, with the highest macrofraunal biomass observed near Bering Strait, in shelf troughs, and at the head of Barrow Canyon. Offshore macrofaunal communities were dominated by bivalves and sipunculids, troughs by polychaetes, and the Alaska nearshore by sand dollars, isopods, and amphipods. Sediment respiration ranged from 38.3 mmol O2/m2/d in the "hotspot" north of Bering Strait to 5.9 mmolO2/m2/d in a central trough of the offshore Chukchi Sea. Total organic carbon was highest in offshore fine silt and clay sediments (1.8%), with average shelf values ranging from 0.5-1%. C/N (weight/weight) ratios in surface sediments were 6-8 in offshore waters (=labile carbon), compared to more refractory organic materials (C/N>9) in nearshore surface sediments. These results will be presented in the context of other recent studies from which a broader understanding of Chukchi benthic community structure is emerging, including the Russian-American Census of Marine Life, Canada's Three Oceans, Shelf-Basin Interactions, and work funded by Shell Oil and Exploration.

Characterization and Comparison of Benthic Biological Communities using Video and Trawling Approaches during COMIDA CAB

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Traditional methods for quantifying biomass and abundance of epibenthic marine communities, such as trawling, are subject to high data variability depending upon gear and deployment. We are using small otter trawls and a submersible video camera to assess baseline population densities of dominant macrobenthic epifauna in the Lease 193 oil and gas exploration area in the Chukchi Sea. In many cases it is possible to directly compare abundance and biomass estimates derived from timed trawling versus videotaped observations. These comparisons show good agreement with the videotaped observations that incorporate dual lasers to provide scale, particularly in the case of epibenthic assemblages of brittlestars that are dominant in many areas of the Lease 193 area. These findings suggest that the much faster deployment and recovery of submersible video equipment relative to trawling may be a useful field tool in assessing changes in arctic epibenthic communities. Videography can also be used over hard substrates such as near-shore habitats and in upper portions of Barrow Canyon, which cannot be trawled. While video imagery cannot be used as readily on hard substrates for quantifying benthic biomass, the imagery nevertheless qualitatively documents biologically rich epibenthic communities in many parts of the Chukchi Sea. Videography also retains its advantage over trawling as a non-destructive sampling technique. Ultimately we expect that this publicly available imagery obtained in 2009 and 2010 (e.g. http://arctic.cbl.umces.edu/web-content/COMIDA09_Video/) can be used as a starting point for developing a more detailed geographical information system for benthic biological communities in the Chukchi Sea.

Terrestrial and marine sources fuel the growth of young-of-the-year Arctic cisco (*Coregonus autumnalis*) as determined from diet and stable isotope analysis

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Arctic cisco (*Coregonus autumnalis*), an important subsistence fish resource in the Colville River, Alaska, are an amphidromous whitefish that spawn in the Mackenzie River of Canada and migrate to Alaska North Slope rivers during their first year of life. Growth during the first year is rapid as they forage in the nearshore Beaufort Sea. Nearshore arctic communities function much like estuaries, assimilating carbon from both marine and terrestrial sources. Here, we examine the trophic pathways of young-of-year Arctic cisco (n = 84) captured near Prudhoe Bay, Alaska, using stable isotope signatures from muscle and diet analysis (stomach contents). Diet analysis provides species-specific information, but only from recent foraging (days). Stable isotope values discriminate between terrestrial and marine carbon sources (δ13C). Average δ13C for all individuals was –25.74‰, with the smallest individuals possessing a significantly depleted δ13C indicative of a stronger reliance of terrestrial carbon sources as compared to larger individuals. As fish length increased, the proportion (both by number and mass) of the nearshore copepod *Pseudocalanus* decreased and the marine copepod *Calanus hyberboreus* increased (ANOVA, $P < 0.01$). Both stable isotope and diet analysis suggest a rapid transition from terrestrial to marine carbon sources over the first year of life. Combining results from multiple trophic indicators retains species level prey data and provides broader long-term measures of trophic ecology.

Benthic and pelagic fish sampling in the northeastern Chukchi Sea

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Fish sampling was conducted in the northeastern Chukchi Sea from July – August, 2010 to characterize species composition, determine abundance levels, and identify distributions. We used a 5-m beam trawl to target benthic fish communities and a 10 x 8-m midwater trawl to target pelagic fish. A suite of environmental characteristics were synoptically measured at each fish sampling site. Deployed at 24 stations, the beam trawl captured 853 fish. These were distributed among 20 species representing eight taxonomic families. Arctic cod (*Boreogadus saida*) were the most common species, composing over 39% of bottom trawl catches. Other prevalent benthic taxa were sculpin (Cottidae, 22%, composed of seven species), eelpouts (Zoarcidae, 14%, composed of four species), and pricklebacks (Stichaeidae, 13%, composed of three species). Total benthic fish density ranged between sites from 108 fish/km2 to 30,967 fish/km2, averaging 7,048 fish/km2. The midwater trawl was operated at 16 stations, including three stations not fished by the beam trawl. Very few fish appeared to be in the pelagic water column: 89 total fish were caught, mainly larvae (<40 mm). Midwater trawl catches were highest at southern latitudes; 72% of the total midwater catch were at the five most southerly stations. Bering flounder (*Hippoglossoides robustus*) and fourhorn poacher (*Hypsagonus quadricornis*) were found north of their typical distribution.

50 years of demersal fishes in the Chukchi Sea

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Assessment of demersal fish in the northeast Chukchi Sea is important because of the potential for changes to the ecosystem with changing climate and anthropogenic use of the region, e.g., oil and gas exploration, fisheries, and vessel use of the area. From 1959 through 2009, data were available from 19 cruises in the Chukchi Sea. Fourteen cruises occurred only in the northeast area with the most recent collections focusing on oil and gas lease sale areas. The remaining five were in the southeast Chukchi Sea and three of these also sampled in Russian waters. All collections occurred in the ice-free months of July-October. More than 80 taxa of fishes in 17 families were captured. Because 11 different types of demersal trawls were used, catch-per-unit-effort could not be standardized across cruises; thus analysis was of fish presence/absence. To analyze fish assemblages and examine community structure, we used hierarchical clustering analyses that grouped stations according to species composition. Fishes tended to cluster by time and location of sample collection, resulting in variations in characteristics of fish assemblages over time. The composition of fish assemblages in the Chukchi Sea was often dominated by the same, dominant species. Over the historic collection period, >90% of the fish collected was composed of 9 species in three families: Cottidae – *Artediellus scaber*, *Gymnocanthus tricuspis*, *Myoxocephalus scorpius*; Gadidae – *Boreogadus saida*, *Eleginus gracilis*; Pleuronectidae – *Hippoglossoides robustus*, *Limanda aspera*, *Pleuronectes quadrituberculatus*. The dominant species differed among collections with place and time. It is unlikely that location per se affected fish assemblages, but rather that the physical parameters associated with those locations were the driving factors. Temperature, salinity, and sediments explained demersal fish assemblages in the Chukchi Sea; these factors are likely to be affected by climate change. Therefore, we speculate that changes in distribution of individual fish species, as might be expected with influences of climate change, could restructure the species composition and spatial extent of fish assemblages.

Estimating diets in threatened eiders using stable carbon isotopes of specific fatty acids

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Threatened Steller's and spectacled eiders rely on benthic habitats of the North Pacific for survival and reproduction, and changes in the quality and quantity of available food resources may be limiting recovery of Alaskan populations. Here we describe a method to estimate eider diet using stable carbon isotope analyses of specific fatty acids (FA). Stable carbon isotopes of FA deposited in animal tissues can serve as markers of their source but are likely fractionated to some extent during digestion, assimilation and mobilization. Knowledge of the amount of such modification is critical in developing this technique. Accordingly, stable carbon isotopic fractionation in adipose was investigated by feeding both species a constant diet for 6 months. Essential FA in the adipose showed varying degrees of fractionation, depending on structure. Stable carbon isotope ratios of long-chain FA, 20:5n-3 and 22:6n-3, did not differ from diet, while 18:2n-6 showed a ~2‰ enrichment. Isotope ratios of 18:3n-3 varied with dietary intake, showing enrichment similar to 18:2n-6 when consumed in relatively large amounts. Discrimination factors were used in combination with a mixing model incorporating FA and lipid concentrations to estimate the diet of eiders fed a binary mixture with contrasting isotopic signatures. Diet estimates varied with FA but mean values closely approximated actual proportions consumed, demonstrating the utility of this method in tracing dietary input in free-ranging eiders.

Speakers: Arctic
Mammals

Acoustic source levels of bowhead moans from acoustic measurements and propagation modeling in the Chukchi Sea

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An array of 43 underwater acoustic recorders was deployed in the Chukchi Sea in the summer of 2009 to measure natural and anthropogenic noise levels and to monitor and detect marine mammal vocalizations. This array included two clusters of 12 recorders each whose purpose was to permit localization of bowhead whale calls during the fall migration. The recorder clusters were arranged in a triangular grid patterns with 8 km spacings. 318 unique calls were identified simultaneously on three or more recorders, making them candidates for localization. Our algorithm imposed time delay and geometric constraints on the calls to ensure localizations were accurate to within 250 meters. 86 unique calls passed these tests. The first part of this presentation discusses the localization technique. The second part describes how acoustic propagation modeling was performed to determine the transmission losses from each recorder location to all points in the array volume. The localization results were then combined with the modeled propagation losses to determine vocalization source levels (and variability) of the bowhead moans, which are compared to the values provided by Cummings and Holiday (1987).

Inter-annual Variability and Exceptional Movements of Western Arctic Bowhead Whales from Satellite Telemetry, 2006–2010

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A cooperative research project began in 2005 to study the movements and habitat use of the western Arctic stock of bowhead whales (*Balaena mysticetus*). Satellite-linked transmitters were deployed on 58 bowhead whales (2006–2010) by Alaskan and Canadian subsistence whalers. Tagging in consecutive years allowed us to examine variability among years, illuminating important aspects of bowhead ecology. For example, whales entered the Bering Sea over a longer time period in 2008/09 (65 d) than in 2009/10 (20 d), and whales in 2008/09 spent more time in the western, versus central, Bering Sea and were farther from the marginal ice edge. As more tags were deployed, we observed movements that were not expected, including: 1) in spring 2010 one whale migrated west to the Chukchi Peninsula, not east to the Canadian Beaufort; 2) two whales (one in 2006 and one in 2010) travelled north of Banks Island before returning to the Beaufort Sea prior to fall migration; and 3) after migrating to the Canadian Beaufort, four whales returned to Barrow (offshore) during summer instead of during fall; one of these whales travelled to the Chukchi Peninsula prior to the fall migration. These movements, whereas exceptional within our tracking data, are unlikely to be rare for the population as a whole and in some cases are corroborated by local observations. Satellite tracking over multiple years will allow us to assess variability in movements and habitat use to assess how bowhead movements may be influenced by currents, ice, underwater noise, and other factors.

Speakers: Arctic
Mammals

A Tale of Two Seas: Lessons from Multi-decadal Aerial Surveys for Cetaceans in the Beaufort and Chukchi Seas

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Three decades of aerial surveys have revealed apparent differences in the consistency of habitat partitioning between the dominant cetacean species in the Beaufort Sea compared to the Chukchi Sea. The Bowhead Whale Aerial Survey Project conducted annual line transect aerial surveys for marine mammals in the western Beaufort Sea from 1979-2010. Analogous surveys in the northeastern Chukchi Sea were conducted between 1982 and 1991, recommencing annually from 2008-2010 as part of the Chukchi Offshore Monitoring in Drilling Area project. In 2007, a landmark year for the Arctic, summer sea ice extent reached a record minimum. In the western Beaufort Sea, belugas and bowhead whales are the most abundant cetaceans; they exhibited consistent habitat partitioning during the pre- and post-2007 time periods: belugas have been found primarily in the outer continental shelf and basin, whereas bowheads have been found primarily in the inner continental shelf. In contrast, in the northeastern Chukchi Sea, gray and bowhead whales are the most abundant cetaceans. Prior to 2007, gray whales were found primarily in coastal or shoal waters, whereas bowhead whales were found primarily in the outer continental shelf. Since 2007, however, bowhead and gray whale distributions have overlapped substantially; although the depth zone of maximum encounter rate is temporally variable, this temporal variability appears synchronous in both species. We discuss oceanographic mechanisms that could potentially cause differences in temporal patterns of habitat use between the Beaufort and Chukchi Seas.

Kinship, group structure and philopatry in beluga whales, *Delphinapterus leucas*: the genetic evidence

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Assessing the advantages of group formation is typically framed in terms of inclusive fitness. Determining the extent to which different types of animal groupings are kin-based is also central to understanding dispersal, and population structure and dynamics in social species. In recent decades, much research has been conducted on movements, dispersal and gene flow in beluga whales, *Delphinapterus leucas*, driven in large part by management needs. By contrast, research on group structure across much of the species range has been limited and no systematic genetic analysis has been conducted to date. Highly gregarious, beluga whales exhibit a wide range of group types, from large herds of >200 whales to small groups of <10 individuals. A number of authorities have assumed that beluga whale groupings are similar to killer whales and pilot whales where closely associated individuals are from the same maternal lineage. We genotyped 451 beluga whales sampled from 62 different groups across the species range, and found: (1) apart from cow-calf pairs, most group-members were not close relatives ($r = 0.0314$), (2) in almost all groups (n=58/62) multiple mtDNA matrilines (n=2-9) were documented within groups, regardless of group size, and (3) despite the low level of observed kinship within individual groupings, close kin ($r=0.35$-0.48) were found across years in the same population, sometimes up to three years apart. These results suggest a unique social system that is not based on high association indices among kin, but high fidelity to natal herd, subpopulation and key locations.

Speakers: Arctic
Mammals

Temporal and Spatial Trends of Current-Use and Legacy Persistent Organic Pollutants in Beluga Whales from Alaska

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The Arctic is considered a major sink for persistent organic pollutants (POPs) arising from long range transport. Cold temperatures in the Arctic reduce POP degradation and facilitate air-to-water exchange, thus enhancing aquatic food web contamination. Studies assessing time and location trends of POPs in Arctic fauna are mainly from Canada, Greenland, Svalbard, and northern Europe using seabirds, ringed seals and polar bears. There are comparatively few trend studies from other locations, particularly Alaska. To provide more information on the status of POPs in this region, liver (n=68) and blubber samples (n=67) were collected in 1989 through 2006 from beluga whales (*Delphinapterus leucas*) from both the Cook Inlet and the eastern Chukchi Sea beluga whale stocks as part of Alaska Marine Mammal Tissue Archival Project. Samples were analyzed for a variety of current-use and legacy POPs. Legacy POPs included polychlorinated biphenyl (PCB) congeners and organochlorine pesticides. Current-used POPs included brominated flame retardants (BFRs) and perfluorinated compounds (PFCs). Legacy POPs were generally higher in Chukchi Sea belugas relative to Cook Inlet and were invariant with respect to beluga collection year. Conversely, current-use POPs generally showed increasing concentration with sampling year. BFRs and PFCs were higher in Cook Inlet belugas relative to the other location suggesting local sources. This study shows that legacy POP concentrations are stable in belugas despite use restrictions and current-use POP concentrations are increasing. This work reinforces the importance of environmental specimen banks as a sample resource for assessing pollution trends.

Acoustic detections of belugas in the northeastern Chukchi Sea between July 2007 and October 2009

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Acoustic recorders have been deployed in the northeastern Chukchi Sea (CS) since July 2006 to monitor natural and anthropogenic ambient sound levels and survey marine mammals, primarily during the open-water season. Since July 2007 this acoustic monitoring program has been active year-long and has provided new insights into the spatio-temporal distribution of marine mammals from late fall until early summer. Here we report on acoustic detections of beluga whales between July 2007 and 2008 and October 2008 and 2009. During the first period belugas were detected between July and October 2007, with most summer detections near Barrow Canyon in July and August. Beluga calls were detected sporadically in November 2007 off Point Lay and consistently between 13 April and 21 June in a broad area 90-150 km off Point Lay and Wainwright. The 2008-09 overwinter detections were consistent with those from the previous year, with few detections in October and November and numerous detections in the spring between 12 April and 9 June. There were only four detection days in the summer of 2009. Recording effort explained at least part of the differences between years. The summer and fall detections were consistent with movement and residency patterns identified in satellite tagging studies. However the spring detections provide new information on the timing and extent of belugas' spring migration through the CS. These results have implications for assessing the impacts of a potential increase in anthropogenic activities in the CS on local beluga populations.

Speakers: Arctic
Mammals

What's in the Mix: Treatment of Ice-Seal Prey Sources within Stable Isotope Mixing Models

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Incorporation of stable isotopes in Bayesian mixing models estimate and attribute proportions of dietary items to a consumer. Stable isotope analysis is a robust technique often used to evaluate carbon and nitrogen sources within the diet of an organism. Mixing models can be employed to infer the importance of particular prey species within ecosystems and estimate temporal trends responding to external variables. Changing sea ice conditions and potentially associated changes in available prey to Arctic pinnipeds make these models invaluable tools. However, variability of lipid content within tissues introduces confounding factors when assessing foraging dynamics of predators. Compared to protein-rich tissues, lipids are depleted in carbon-13 thus analysis of non-lipid-extracted prey tissues may lead to a distortion of carbon signatures relative to assimilated food. Our results demonstrated that using non-lipid-extracted prey samples in mixing models mischaracterized pelagic foraging ringed seals, *Pusa hispida*, as benthic foragers. Though we also lipid extracted the predator tissues, there was no significant difference in δ13C. Lipid-extracted prey sources in mixing models accurately portrayed ringed seals as pelagic and bearded seals as benthic feeders. Examination of seal tissues documented inter-annual differences in the proportions of prey items. Ringed seal diet consisted of higher proportion of pelagic fishes in 2003 relative to 2009 diets that had more crustaceans or similar low trophic level species. In 2003 and 2009, bearded seals (*Erignathus barbatus*) fed on a higher proportion of benthic species compared to 2007 and 2008. Isotopic mixing models are powerful tools in marine ecosystem studies, though care should be taken with sample treatment as lipid-removal is essential in preventing misinterpretations of diets.

Pacific walrus behaviors during summer and autumn, 2007-2010

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Summer sea ice habitat of the Pacific walrus is rapidly changing. To characterize walrus movement and foraging patterns relative to sea ice availability, we tracked over 230 walruses with satellite tags in the Chukchi Sea from 2007 to 2010. After entering the southern Chukchi Sea in early June, walruses moved quickly with the retreating ice into the Hanna Shoal region in the northeastern Chukchi Sea and offshore areas of northern Chukotka and Wrangel Island in the western Chukchi Sea. In three of the last four years in the eastern Chukchi Sea, the sea ice disappeared from over the continental shelf in early autumn, prompting thousands of walruses to haul out onto the northwest coast of Alaska. Coastal haulouts also formed along northern Chukotka, but at different and sometimes much greater magnitude than in northwest Alaska. The novel formation of these coastal haulouts in early autumn by adult females and young are directly related to the loss of sea ice over the shelf, and were associated with the trampling deaths of thousands of young walruses and restricted access to offshore foraging areas. Walruses from these haulouts generally foraged within 50 km of shore in Alaska and within 150 km of shore in northern Chukotka. In late fall, walruses in northwestern Alaska quickly moved to a prominent haulout in northern Chukotka where they resumed near shore foraging. These behaviors may become more consistent in future decades as summer sea ice conditions in the Chukchi Sea transition into longer ice-free periods.

Predicting the seasonal distribution of sea ice habitats used by female polar bears in the Beaufort Sea

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Polar bears (*Ursus maritimus*) are dependent on sea ice and most maintain contact with it throughout the year. To predict the distribution of polar bears in the Beaufort Sea (BS), we built resource selection functions. For 1999-2008, we used satellite telemetry data from bears and fine-grain environmental data to identify habitats selected by polar bears. Ocean depth, total ice concentration, and proximity to the interface between different ice types explained most habitat selection patterns. During the spring and summer melt habitat selection was bimodal. Most bears used low concentration sea ice near shore and far from high ice concentration thresholds; however, some bears used high concentration sea ice offshore. In autumn bears selected high concentration ice and young ice over shallow waters. In winter and early spring, polar bears selected the shear zone boundary between land fast ice and drifting pack ice in shallow waters. Tests with independent data showed a close agreement with the predicted distribution of preferred habitats and locations of radio-tagged polar bears. These results confirm past observations that polar bears prefer sea ice over shallow shelf waters. Selection of low concentration ice over shallow waters during spring and summer, however, contrasts with earlier findings that polar bears prefer sea ice concentrations ≥ 50%. Selection for shallow water sea ice suggests two consequences to BS polar bears. First, these habitats are most vulnerable to loss from climate warming. Secondly, the proximity of preferred habitats to human activities increases the likelihood for human-bear interactions.

Modeling Causeway Impacts on Coastal Morphology in the Sagavanirktok River Delta

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Shoreline change on the Arctic coast has become a major issue as high erosion rates threaten coastal communities; oil, gas and mining infrastructure; and critical habitat for many species. The effects of global climate change in the Beaufort Sea are having a significant impact on the retreat of sea ice. Maritime activity and resource exploration is expected to increase as more open water becomes accessible. The increase in activity in the Arctic will inevitably increase the demand for more coastal infrastructure. Solid filled causeways are currently used along the Beaufort Sea coastline to support oil and gas drilling operations and provide access for ship and barge landing on a relatively shallow coastline. The solid filled causeways, extending offshore, alter the coastal hydrodynamics that move sediment along the coast. Perturbations in the sediment transport system alter coastal morphology often resulting in unnatural erosion and accretion. This research investigates the impacts that the Endicott causeway, located in the Sagavanirktok River delta on Alaska's North Slope, has on sediment transport in the delta. In particular the research addresses the sedimentation occurring in the lagoon located between the Endicott Causeway and the west channels of the Sagavanirktok River delta. The coastal hydrodynamics and morphology are simulated in a 2D numerical model and verified with data collected in past monitoring programs and during recent site visits. Model simulations with and without the causeway in-place provide critical information for understanding the impacts the Endicott causeway has on the Sagavanirktok River delta morphology.

Oil Development Impacts on Subsistence - Monitoring and Assessing Mitigation

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The purpose of this project is to develop a systematic method to monitor and evaluate the success of specific mitigation measures as related to industrial exploration and development of hydrocarbons in the coastal and offshore environment of Alaska, especially as they relate to potential impacts on subsistence hunting activities near Nuiqsut. The objective is to develop a prototype method based on a review of six North Slope Alaska oil development projects: Alpine (including Alpine Satellites) Endicott, Meltwater, Northstar, Oooguruk, and Tarn. This study, being conducted under contract to the U.S. Department of the Interior, Bureau of Ocean Energy Management, Regulation, and Enforcement, will evaluate the effectiveness of industry's pre-lease mitigation strategies and post-lease operations.

This presentation is based on an inventory of concerns and mitigation proposals and requirements associated with the six projects and a descriptive analysis. The inventory, developed through systematic review of federal, state and municipal environmental and permitting documents, identified 303 relevant documents and yielded 1,620 analytic records. The purpose of the analysis is to guide the development of interviews with industry and government informants. Analysis results identify 1,213 mitigation decisions over the six projects covering such mitigation categories as pipeline elevation and placement, aquatic habitat protection, helicopter and airplane management, community consultation, and research on caribou displacement. The presentation tracks the incidence of concerns, mitigation ideas, and mitigation decisions by type of impact and mitigation.

Speakers: Arctic
Humans

A community-of-practice approach to assess the nature and impacts of sea-ice changes on Bering and Chukchi Sea ice users

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Recent changes in the summer ice cover of the Pacific (sub)arctic sector are among the most substantial anywhere in the Arctic. In a collaborative, interdisciplinary approach that relied strongly on Indigenous community sea-ice experts, we have examined changes in the seasonal patterns of sea ice distribution in the Bering and Chukchi Seas over the past three decades. The work melds community-based observations and Indigenous knowledge, remote-sensing and a geophysical sea-ice observatory. In the presentation we will discuss how our research group formed and how Indigenous and local sea-ice knowledge and geophysical studies can complement each other. The findings and networks established through this work informed and contributed to the Study of Environmental Arctic Change's (SEARCH) Sea Ice for Walrus Outlook (SIWO; see presentation by G. Hufford). While the work generated important insights into how large-scale changes in the sea ice cover play out at the local scale and how this impacts activities such as subsistence hunting, it can also be viewed as an attempt to establish a community of practice to improve weather-service products and safety of hunters at sea.

The Arctic Marine Synthesis: Using maps to influence science and policy in the Chukchi and Beaufort seas

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Over the last 40+ years, scientists have collected physical and biological information in Alaska's Arctic Ocean. Such data include water depths, ocean circulation, sea surface temperatures, sea ice coverage, primary production rates, benthic hotspots, seabird colonies, marine mammal concentrations, and climate change predictions.

Audubon Alaska, in cooperation with Oceana, compiled over 400 reports and journal articles, and ~125 spatial datasets representing the current state of knowledge about the Chukchi, Beaufort, and Northern Bering seas. Source data covered various geographic areas and time periods; were collected at a range of spatial scales using a variety of methods; and were stored in a number of different formats including paper maps, spreadsheets, web databases, GIS files, and satellite imagery. These data were converted to a single spatial format with a common set of fields and attributes. Using this information, Audubon created an atlas of 44 maps depicting the interacting and overlapping physical and biological factors at play in the Arctic marine environment.

In a spatial context, this project has connected the dots between a wide range of scientific research and has shed light on important wildlife habitats and additional research needs. Example science and policy applications include the USGS data gaps analysis; USFWS polar bear critical habitat designation and the Pacific walrus status review; the IUCN effort to map Ecologically and Biologically Significant Areas and World Heritage Sites in the circumpolar Arctic; and Oceana's effort to model Important Ecological Areas.

Keynote: Bering Sea and Aleutian Islands

Understanding Ecosystem Processes in the Bering Sea

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Following warm years from 2001 to 2005, the eastern Bering Sea subsequently cooled with a sequence of very cold years from 2008 to 2010. In 2007, the North Pacific Research Board (NPRB) and the National Science Foundation (NSF) entered into a historic partnership to support a comprehensive $52 million investigation of the eastern Bering Sea ecosystem to understand how climate change and associated changes in sea-ice is impacting the Bering Sea ecosystem and the consequences of these changes on lower trophic levels for fish, seabirds, marine mammals, and ultimately people. The "Bering Sea Project" integrates two research programs, the NSF Bering Ecosystem Study (BEST) and the NPRB Bering Sea Integrated Ecosystem Research Program (BSIERP). This six-year study of the Bering Sea ecosystem links nearly a hundred principal scientists through a vertically integrated process and modeling program. Field research began in 2007 and reached full speed the following year, with at-sea sampling conducted over three years from February through October of 2010. With the conclusion of field sampling, multiple efforts are now underway to integrate and synthesize the substantial data collection and information collected. In our presentation, we will use a series of vignettes that begin to describe the synthesis of the study results.

Mini Keynote: Bering Sea and Aleutian Islands

The Bering Sea Ecosystem Professional Development Workshop – Transforming BEST-BSIERP Science into Educational Resources

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In an historic integrated ecosystem research program, the Bering Ecosystem Study (BEST) and the Bering Sea Integrated Ecosystem Research Program (BSIERP) partnered to understand the impacts of climate change and dynamic sea ice cover on the eastern Bering Sea ecosystem. As part the outreach program, educators accompanied researchers to remote field sites during the first two field seasons.

In October 2010, the North Pacific Research Board, the Arctic Research Consortium of the US (ARCUS), COSEE Alaska, NOAA, and the Monterey Bay Aquarium Research Institute brought teachers and scientists back together for a four-day professional development workshop. Participants included teachers who went to sea with BEST-BSIERP researchers through teacher research experience programs, and Bering Sea community teachers from St. Paul, Emmonak, and Nome, as well as project scientists interested in gaining expertise in broader impacts activities.

Using the BEST-BSIERP hypotheses and focal areas as a guide, educators and researchers presented, interacted, and learned from each other on site and virtually. Teachers refined previous lessons and created new educational materials based on researchers' presentations, while scientists gained insights into how to communicate to educational audiences.

The resources generated during the workshop make up the Bering Sea Collection, a body of educational resources hosted online through ARCUS' PolarTREC Learning Resources database and linked to the BEST-BSIERP web pages. The Collection includes individual activities, lesson plans, videos, and presentations. Through the workshop, project researchers achieved broader impact goals and helped create resources that will educate the next generation about this complex ecosystem study.

The BEST years from a mooring array's perspective

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We describe initial results from a temperature, salinity and current meter-mooring array deployed on the eastern Bering Sea shelf from July 2008 to July 2010. The circulation resultant from individual storm events varies across the array as do water column shears. Band-pass filtering highlights the ocean's response within different frequency intervals. In the mid-frequency portion of the spectrum (1.5-14 days), the velocity variance increases in the fall to spring time period relative to the summer months. In the low frequency portion of the spectrum (14 days and longer), extended periods of enhanced advection (5-10 cm/s for 2-8 weeks) are observed at many of the mooring locations, during which times the average velocity shear can exceed 5 cm/s between the 5 m and 30 m depth levels. The observations suggest that interaction of the non-uniform and temporally variable wind field with the ocean's natural response leads to appreciable net cross-isobath transport. Although both winters resulted in extensive sea ice cover, the wind forcing was considerably different. The inter-annual differences in wind mixing resulted in varying evolutions of the water column stratification. In October 2008, strong winds in one major storm event resulted in significant water column overturn whereas the breakdown of stratification in fall of 2009 resulted in a more gradual erosion of the pycnocline. Likewise, stronger winds in the spring of 2009 accompanied a delayed onset of re-stratification while weaker winds in the spring of 2010 accompanied an earlier re-stratification.

The effect of bioturbation on iron and manganese oxide reduction pathways in Bering Sea shelf sediments

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The role of bioturbation in the cycling and reduction of iron (Fe) and manganese (Mn) oxides was examined in the sediments of the southeastern Bering Sea, an area known for high levels of primary productivity, which is iron-limited in off-shore waters. Assessment of the relative importance of these remineralization pathways will help us further understand the dynamics of sedimentary respiration and the potential influence on overall productivity. At each sampling location, sediment oxygen consumption was directly measured using incubation cores. Iron and Mn oxide concentrations and their reduction rates were determined. Bioturbation rates were also quantified using profiles of excess 234Th. Results varied across the Bering shelf. Average rates of bioturbation were highest in the northern region, and lowest in the off shelf region. Iron oxide reduction followed the same trend with the highest rates in the northern and middle regions. These were the only regions where Fe oxide reduction, as a fraction of total oxygen consumption, positively co-varied with bioturbation rates. Conversely, Mn oxide reduction was found to be of minor significance, with low rates found across the shelf. These results indicate that Fe oxide reduction is a significant pathway for the degradation of organic matter in the northern and middle shelf regions, where organic matter supply and benthic biomass densities are high. A possible shift in energy flow from the benthic to the pelagic ecosystem due to current trends in climate change may have dramatic impacts on the productivity of this region.

Volcanic eruptions, landscape disturbance, and potential impacts to marine and terrestrial ecosystems in Alaska: an example from the August 2008 eruption of Kasatochi Volcano and other noteworthy eruptions in Alaska

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Large volcanic eruptions have the potential to radically alter or destroy marine and terrestrial ecosystems. The magnitude and sometimes-prolonged nature of volcanic activity can compromise ecological habitat such that areas important to the success of a particular species are no longer attractive or usable. Kasatochi volcano erupted violently on August 7–8, 2008 in a series of explosive events that produced SO2 rich ash-gas plumes that reached 14 to 18 km above sea level and were tracked around the globe. Kasatochi island is an important nesting area for seabirds and a long-term biological study site of the USFWS. The eruption generated hot pyroclastic flows and ash fall over all flanks of the island that destroyed preexisting habitat. Pyroclastic deposits are several tens of meters thick and the seaward extent of these deposits increased the diameter of the island by about 800 m. Wave and gully erosion have begun to modify the surface mantle of volcanic deposits and locally have exhumed pre-eruption surfaces. Analysis of satellite images and field studies have shown that by September 2009, gully erosion removed 300,000–600,000 m^3 of mostly fine-grained volcanic sediment from the volcano flanks and much of this has reached the ocean. Sediment yield estimates from two representative drainage basins are about 10^4 $m^3km^{-2}yr^{-1}$ and are comparable to sediment yields at other active volcanoes. Average annual erosion rates of the coastline are 80 to 140 myr^{-1}. At these rates, it could take 3–5 years for wave erosion to reach the pre-eruption coastline. As of September 13, 2009, the total volume of material eroded by wave action was about 10^6 m^3.

Volcanic eruptions as large or larger than the 2008 Kasatochi eruption are common in the geologic history of the Aleutian arc. Within the past several thousand years there have been many eruptions that produced >10 km^3 of volcanic material that covered extensive areas of the Alaska Peninsula and some Aleutian Islands with unknown ecological impacts. Study of the Kasatochi eruption is providing a much-needed opportunity to evaluate the biological and geological linkages that control habitat recovery following a severe natural disturbance.

Benthic biogeography & foodwebs in Beringian canyons

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Submarine canyons globally are recognized as rare habitats, occupying <4% of the world seafloor and serve as conduits for organic and inorganic matter moving between deep basins and continental shelves. Carbon flux rates and physical processes within canyons often support high biomass and diversity. We examined foodweb structure and species distributions in upper depths of two canyons in the Bering Sea, Alaska.

In situ submersible and ROV examinations of Zhemchug and Pribilof Canyons in 2007 and subsequent taxonomic and geospatial seabed analyses have provided a basis for biogeographical comparison of these two submarine canyons incised in the southern Beringian Margin. Geomorphology, and substrate features such as sea ice-conveyed “dropstone” deposition patterns unique to each canyon support different benthic assemblages between canyons at depths from 300 to 1,000 meters.

Analysis of stable carbon and nitrogen isotopes across a range of epibenthic megafaunal foraging guilds from within canyon collections provides insights regarding carbon sources and foodweb structure in the upper reaches of the canyons. Stable carbon isotope data coupled with mounting evidence from visual canyon investigations and recent core drilling in the vicinity has furthered consideration of the notion that methane hydrate based chemosynthetic pathways may contribute to epibenthic and demersal foodwebs within shelf edge chasms. Characterizing the distribution and trophic position of corals, sponges, and other species from the canyons serves as an initial basis to contrast canyon communities and contributes to baseline data from which to compare canyons to non-canyon regions of the Bering Sea slope.

Isotopic assimilation in the bivalve *Nuculana radiata*: possible trophic consequences in changing Bering Sea ice-benthic coupling

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The close coupling of sea ice-benthic trophic processes are a general characteristic of Arctic systems, including the Bering Sea shelf. The predicted climate-induced reduction in sea ice presence could lead to large ecosystem-wide impacts on trophic level interactions; however, species-specific consumer dependence on ice-algal production needs to be assessed. Our objectives were to utilize stable carbon and nitrogen isotope ratios as naturally occurring food source markers to track feeding in the benthic bivalve, *Nuculana radiata*. Using isotopically enriched (δ13C and δ15N) ice-algal food, we determined the isotopic assimilation in lipid-extracted muscle, isolated lipid extracts, and mass-balanced whole clams in two experiments. Isolated *N. radiata* jar experiments over 42 days revealed an assimilation rate in muscle tissue no greater than 0.010% day^{-1} for δ13C and δ15N, with nearly three times higher rates in lipid extracts for both C and N. Mass-balanced whole clam enrichment was 0.017% for δ13C day-1 and 0.020% for δ15N day^{-1}. In contrast, *N. radiata* incubated in sediment cores over 18 days had lower isotopic assimilation rates than those in the sediment free jars. This suggests that clams in the cores may be using food sources available within the sediments in addition to the experimentally added ice algal food. Overall, assimilation in *N. radiata* was very slow and complete isotopic turnover in both experiments would likely be on the order of several months.

Effects of temperature and density on spatial dynamics and interactions among Bering Sea groundfishes

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One of the most direct effects of climate variability on fish and shellfish populations is a spatial shift in distribution in response to temperature changes. Northward shifts during warm years have been documented for many regions, including the eastern Bering Sea. Similarly, temperature-related changes have been observed in the depth distribution of fish and invertebrates. However, these shifts do not represent simple linear responses to temperature, as evident in non-linear changes over time that are unrelated to temperature. Changes in distribution are not spatially uniform and may be affected by the abundance of the species and by the abundance and distribution of its competitors and predators. Trawl survey data from the eastern Bering Sea for 1982-2010 were used to examine major modes of spatial variability in the abundance of 46 groundfish taxa, their associated time trends, and the relative importance of temperature and total abundance (density) in explaining the observed trends. Results suggest that changes in abundance are strongly associated with changes in the spatial distribution of most species, while changes in temperature are of secondary importance or are not significant. Together, these two factors account for most of the variability in the major mode of spatial variability for 39 of 45 species examined. In addition, significant residual trends over time were evident in most taxa even after accounting for the effects of temperature and density, suggesting long-term directional shifts in the spatial distribution of many species. Results highlight the importance of spatial dynamics in structuring trophic interactions among species.

The 2010 eastern and northern Bering Sea shelf bottom trawl survey; a first-time synoptic view of groundfishes and crabs

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The twenty-ninth annual bottom trawl survey of the Bering Sea (BS) continental shelf was conducted during the summer of 2010. In addition to supporting annual stock assessments of groundfishes and crabs, the BS trawl survey provides a valuable time series for analyzing trends and ecological relationships of epibenthic macrofauna and environmental factors in support of multiple projects for the Bering Sea Integrated Ecosystem Research Project (BSIERP). This year's survey expanded northward to the Bering Strait and represents the most synoptic trawl survey coverage of the BS shelf to date. The purpose of the northern BS extension was to establish baseline information for commercial crab and groundfish species as a part of a study examining the loss of seasonal sea ice due to climate change. Standardized biological sampling of crab and groundfish resources was done at 142 northern extension stations in addition to the 376 standard annual stations. Bottom temperatures measured during the survey ranged from -1.6° to 12.3°C and mean bottom temperatures of the standard eastern BS shelf area continued a cold trend that began in 2006 where the cold pool extends southward down the middle shelf into Bristol Bay. Northern area catches were smaller compared to the standard area, but distributions of some major species including Alaska plaice, yellowfin sole, and snow crab extended significantly into the northern shelf where they were the most abundant species. Bering flounder, overall a less abundant species, was found to have a little over 50% of its estimated biomass in the northern area.

Landscape genetics of Pacific cod in the Bering Sea and Aleutian Islands

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Tagging and maturity studies suggest that more than one discrete population of Pacific cod (*Gadus macrocephalus*) exists within the Bering Sea/Aleutian Islands (BS/AI) management area of Alaska. This hypothesis was tested via a fine scale study of genetic population structure within this large marine ecosystem. Nine samples were suveyed (96 fish per sample) using 19 microsatellite DNA markers. Samples were taken from spawning fish from the western Aleutian Islands to Unimak Pass and as far north as the Pribilof Island area. The data provides evidence for limited connectivity among spawning groups. In particular, the Unimak and Pribilof samples appeared to be genetically distinct from other groups, and within the Aleutian Islands, dispersal appeared to be limited by distance rather than oceanographic features.

Natal source contributions of Pacific cod recruits in the southeastern Bering Sea

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The population structure of southeastern Bering Sea (EBS) Pacific cod (*Gadus macrocephalus*) remains unresolved. One method to elucidate population structure is through chemical and microstructure analysis of otoliths. Fish from regions with distinct water chemistries can be differentiated based on their otolith signatures. We investigated the natal source signatures of larval and juvenile EBS Pacific cod collected in 2006 and 2008 using otolith chemistry and microstructure. Larvae were collected within the Unimak Pass-Alaska Peninsula region (UP-AP), considered a primary spawning location, and evaluated as a potential source for juveniles collected throughout the EBS. Larval and juvenile otolith natal signatures (Li:Ca, Mg:Ca, Mn:Ca, Cu:Ca, Zn:Ca, Sr:Ca, and Ba:Ca) were examined using laser ablation inductively coupled plasma mass spectrometry. In both years, natal source signatures differed between groups of larvae collected north (EBS) and south (GOA) of Unimak Pass. Discriminant function analysis correctly classified 84.5% and 83.6% of larvae in 2008 to the EBS and GOA, respectfully. Average hatch dates of larvae collected in the vicinity of Unimak Pass in both years were later than those for juveniles. Average hatch dates of juveniles differed between years: March 12 (±2d) in 2006 and February 10 (±2d) in 2008. It is unclear whether this difference is due to variation in spawning time or recruit survivorship. This study supports the use of otolith analysis to elucidate population structure of Pacific cod recruits within the eastern Bering Sea.

Age-0 walleye pollock late-summer and early-fall distributions: the intrigue deepens

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Combined acoustic, midwater trawling, surface trawling, and oceanographic surveys in the Bering Sea (2008-2010) have provided new insight into the late-summer/early-fall distributions of age-0 walleye pollock. It was previously thought that age-0 pollock were primarily found in the Middle Domain with high densities near the pycnocline. We now know that in 2008-2010 age-0 pollock were also found in large (>50 m high, several km long) aggregations in deep (>100 m bottom depth) Outer Domain areas, and that the deep biomass may exceed that found in surface waters. A high-resolution survey of age-0 pollock in fall 2010 confirmed that deep aggregations in the study area (166°0'W-167°0'W, 54°45'N-57°0'N) were distributed continuously in the Outer Domain at bottom depths of ~120-180 m. Sampling within the larger BASIS survey area (161°0'W-172°0'W, 54°30'N-65°30'N) suggested that deep age-0 pollock aggregations may have been present over much of the 100-200 m contour regions in the BASIS survey area. We are now evaluating relationships between oceanographic characteristics (e.g. pycnocline strength and depth, surface and bottom temperatures) and biomass of age-0 pollock in surface and deep water aggregations. Preliminary findings suggest that high numbers of age-0 pollock are associated with the pycnocline when water column stability is high and that the presence of a large cold pool, such as observed in 2010, may influence the horizontal extent of deep aggregations. This research is a key component in understanding distributions and whether the late-summer to early-fall period is critical to the overwintering survival of age-0 pollock.

Alternating climate conditions influence walleye pollock early life stages in the southeastern Bering Sea

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We examine the hypotheses that temperature conditions in the southeast Bering Sea influence the densities and distributions of walleye pollock (*Theragra chalcogramma*, pollock) early-life stages by characterizing years as either cold or warm based on sea surface temperature anomalies. We quantified stage-specific changes in spatio-temporal distribution under cold- and warm-water conditions using centers of distribution and generalized additive models. Our analyses show that all pollock early-life stages shift shoreward or east under warm conditions relative to cold, similar to spatial shifts seen in distributions of sub-adults and adults. Temporal distributions were used to address the hypotheses that spawning, hatching, and larval development are delayed under cold conditions. We found evidence of delayed hatching and larval development through feeding and notochord flexion. We were unable to confirm whether timing of spawning or timing of juvenile transition varied with temperature. However, growth rates through the juvenile stage support the notion of delayed juvenile transition as well as delayed larval development. Furthermore, mortality rates indicate significant loss of pollock early-life stages in cold conditions relative to warm. Our data indicate that future shifts in environmental conditions will have profound influences on the early-life stages of an economically and ecologically dominant member of the Bering Sea community.

Genetic population structure of snow crab (*Chionoecetes opilio*)

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The snow crab (*Chionoecetes opilio*) is a cold water crab distributed throughout the high latitude waters of the Pacific, Atlantic and Arctic Oceans. It has been recently observed that a northward range shift may be occurring due to a number of factors, including environmental, ecological and anthropogenic forces. In the Bering Sea, snow crab are an economically valuable species comprising one of the largest crab fisheries in the world. Currently, there is little known about the genetic population structure within their Pacific/Arctic range and the Eastern Bering Sea stock is managed as a single panmictic population. The goal of our research is to better define population structure by using microsatellite analysis techniques. Genetic analysis of approximately 600 specimens from numerous locations throughout their range was conducted and results are currently being combined with ecological knowledge of the stock to identify whether or not distinct population subunits occur. Snow crab have a long larval dispersal phase lasting from approximately 2-4 months, which would support the hypothesis of a large degree of genetic mixing; however, areas of potential larval retention have recently been hypothesized which may support population divergence. Deciphering population structure throughout the highly exploited Bering Sea populations is not only important for proper management of the current fishery, but for areas of the arctic which are “downstream” and may see fishing pressures in the future.

Age, growth, and maturity of the roughtail skate, *Bathyraja trachura* (Gilbert, 1892) from the eastern Bering Sea

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Fishery landings of skates in Alaskan waters surpass those of all other U.S. states combined. Many skates possess life history characteristics that may make them vulnerable to exploitation; therefore, the accurate assessment of growth rates, longevity, and reproductive productivity is indispensable in developing management plans. The objectives of this study were to provide age estimates and describe growth characteristics of *Bathyraja trachura* from the eastern Bering Sea, specifically examining longevity, size and age at maturity, variation in these traits between sexes, and potential differences in growth between two marine ecosystems. Age estimates were determined using counts of vertebral bands in both unstained thin sections and those prepared using a histological method. Histological preparation elucidated banding patterns and resulted in higher age estimates than unstained thin sections. Ages from histological sections ranged from 0 to 36 years, with a maximum age estimate of 35 and 36 years for males and females, respectively. Of the seven models applied, the Gompertz growth function based on histological sections provided the best description of growth (L_∞ = 974.3 mm TL; k = 1.8; g = 0.09). No significant differences were detected between the growth of males and females. Median length and age at 50% maturity were estimated at 753.1 mm and 22.7 years for males and 818.9 mm and 27.3 years for females. The results of this study may indicate a latitudinal pattern in size and growth, with individuals from the eastern Bering Sea growing more slowly and reaching higher maximum ages than previously reported for specimens collected off the western coast of the United States. The results of age-structured demographic analyses will also be briefly discussed.

Steller sea lion trends from 2000 to 2009 were not associated with Atka mackerel fishery indices in the western and central Aleutian Islands

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The draft 2010 Biological Opinion (BiOp) concluded that the relative intensity of groundfish fisheries for Atka mackerel and Pacific cod in the western and central Aleutian Islands was negatively associated with Steller sea lion population trends since 2000. We applied Generalized Estimating Equation models to Steller sea lion census data to test whether numbers of sea lions or changes in numbers of sea lions were indeed related to the frequency of trawling (number of hauls) or amounts of Atka mackerel caught within 10, 20 or 40 nautical miles of sea lion rookeries and haulouts in Fishery Management Areas 541, 542 and 543 from 2000-2009. We considered the total amounts of fish removed within each zone as measures of possible depletion of sea lion prey, and used the average catches per haul within each zone as localized relative measures of stock size of Atka mackerel available to sea lions. None of our models found a relationship between measures of Atka mackerel biomass and numbers of sea lions at rookeries and haulouts. Nor did our models detect a negative relationship between fishing effort (number of hauls and total catch) and sea lion numbers or population trends. However, three models found small positive associations between fishing and sea lion numbers. Our findings are not consistent with the a priori expectation that lower sea lion numbers were associated with greater fishing effort. The data from the Atka mackerel fishery do not support the contention that sea lion trends were negatively associated with groundfish fisheries in the western and central Aleutian Islands.

Differences in at-sea foraging behavior of chick-rearing black-legged kittiwakes nesting at three Bering Sea colonies

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The at-sea distribution of breeding seabirds should reflect predictable patches of prey within commuting distance of breeding colonies. Reproductive success and, ultimately, population size should reflect the proximity of colonies to predictable prey patches. We compared the foraging behavior, breeding performance, and diet of black-legged kittiwakes (*Rissa tridactyla*) nesting at 3 colonies in the SE Bering Sea: 2 colonies on the continental shelf (St. George and St. Paul islands in the Pribilofs) and 1 colony in the basin (Bogoslof Island). Food availability was lower at the Pribilofs compared to Bogoslof, as indicated by lower chick feeding frequencies and nestling survival, higher adult stress hormones and less fish biomass in kittiwake diet. GPS tracking revealed that Pribilof kittiwakes undertook longer distance foraging trips at night, whereas foraging trip distance of Bogoslof kittiwakes did not differ between night and day. St. Paul kittiwakes commuted long distances to feed on juvenile pollock overnight, while St. George kittiwakes commuted long distances to the basin, up to 120 km past the shelf-break, to feed on lanternfishes overnight. Bogoslof kittiwakes also fed largely on lanternfishes, but much closer to the colony. The long distance overnight foraging trips of Pribilof kittiwakes were apparently in response to the scarcity of predictable patches of juvenile pollock within commuting distance, either on the shelf or over the shelf-break. The long-distance overnight foraging trips by Pribilof kittiwakes are indicators of poor foraging conditions at these two colonies. Future studies will reveal whether Pribilof kittiwakes are experiencing chronically low productivity due to the shifting distribution and abundance of juvenile pollock.

A comparison of two years of winter migrations of Black-legged Kittiwakes breeding on the Pribilof Islands

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Seabirds typically alternate breeding seasons with time away from the colony feeding in habitats or regions that can differ from those experienced while breeding. The effect of this time period on the wintering grounds on processes such as breeding success and population dynamics is not well understood. Here we compare the winter migrations of Black-legged Kittiwakes (*Rissa tridactyla*) from two breeding colonies in the Bering Sea: St. Paul and St. George, in the Pribilof Islands. Although the subsequent breeding success of kittiwakes from these two colonies is highly correlated during the summer, they have contrasting population trends. Using geolocation loggers, forty-six Black-legged Kittiwakes were tracked over the winter of 2008-09; and forty-eight birds were tracked over the winter of 2009-10. Sea ice extended to the Pribilof Islands during both winters while an El Niño event occurred during the winter of 2009-10. In these consecutive winter seasons, kittiwakes from both colonies dispersed over the entire North Pacific Basin north of the North Pacific Transition Zone with the majority of birds heading either south or west. Birds from both colonies shared core areas each season, however there was a high degree of spatial variation in the migration of individual birds.

Stomach contents and stable isotope signatures quantify contrasting foraging patterns and diet of Thick-billed Murres and Black-legged Kittiwakes in the central Bering Sea, July and August 2008, 2009

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We examined wet stomach contents and stable isotope signatures (δ13C, δ15N) of feather, muscle and liver to better understand the foraging ecology of Black-Legged Kittiwakes (*Rissa tridactyla*), and Thick-Billed Murres (*Uria lomvia*) in the central Bering Sea. We collected specimens at sea during the breeding seasons of July and August 2008 and 2009. These two species represent contrasting seabird foraging guilds; kittiwakes are lightly-loaded, wide-ranging plunge-divers, whereas murres are densely-muscled pursuit-divers with more limited range. Spatial analyses of muscle and liver isoscapes quantified contrasting foraging patterns that reflected physical and biological constraints of a central place foraging regimen as expressed in these contrasting guilds. During the breeding season murres likely foraged more consistently in distinct regions N-NW of St. Paul Island, S-SW of St. George Island, and immediately surrounding Bogoslof Island, whereas kittiwakes foraged more widely across the study area. Differences in measures of dispersion among isotope signatures elaborate on these patterns by clearly illustrating a transition in murre foraging effort from free-ranging (pre-breeding) to central place (breeding) regimes. The times at which birds were collected, and the species present in their stomachs, indicated that many birds of both species were foraging primarily during periods of very dim, crepuscular light. In 2008 murre stomach contents (biomass) were dominated by euphasiids, but in 2009 contained a more varied diet of amphipods, squid, Smoothtongue (*Leuroglossus* spp), and Walleye Pollock (*Theragra chalcogramma*). Kittiwake stomachs were dominated by myctophids (*Stenobrachius* spp) in both years, but pollock became another important food item in 2009.

Modeling storm surge and sediment transport to forecast the health of nesting seabird populations in the Yukon-Kuskokwim Delta

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One of the largest intact arctic river delta systems in the world, the Yukon-Kuskokwim Delta provides important nesting habitat for seabird populations, including the spectacled eider, and may shelter more species as climate change alters migration patterns. Although normal tidal forcing introduces seawater several miles into the interior along rivers, rising sea levels and increased storm frequency and intensity may raise salinity in interior creeks and ponds and lead to high mortality among eider ducklings. This Delft3D hydrodynamic model predicts inland seawater penetration due to storm surge and identifies interior locations susceptible to saltwater contamination. The YK Delta lacks adequate water level and tidal history, as well as high-resolution remote sensing resources; therefore, spatial bathymetric field data was collected and processed to refine a coarse 2-arc-second digital elevation model. The subsequent Delft3D grid was forced with tidal data and was calibrated with temporal sediment and velocity field data. In addition, the model is designed to simulate coastline sediment deposition and changes in drainage patterns that further encourage saltwater retention in inland ponds. As an initial step of a larger effort to consider the effect of sea-level rise, arctic storms and erosion on Alaskan coastlines, this study concentrated on the Kashunuk River in the heart of the YK Delta. Although even large storms are currently unlikely to catastrophically raise salinity levels in interior ponds, the combination of rising sea level and storm surge may substantially increase inland salinity and, correspondingly, mortality in eider nesting populations.

Ashes to Ashes: Destruction and subsequent response of a seabird colony after the volcanic eruption of Kasatochi Island

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Kasatochi Island, located in the central Aleutian Islands, was one of nine AMNWR annual monitoring sites and supported a rich community of seabirds, including hundreds of thousands of auklets, storm-petrels, and gulls. The island erupted on 7 August 2008, burying the entire surface under meters of ash and pyroclastic flow material. We made visits to Kasatochi during the summers of 2009 and 2010 to document response of wildlife to the destruction of terrestrial habitat. Early in the season in 2009 and 2010, large numbers of seabirds returned to Kasatochi, with similar on-island and nearshore abundance and distribution patterns as those before the eruption. Using time lapse cameras and song meters, we found that auklets, storm-petrels, and ancient murrelets not only returned to former nesting colony sites but persisted throughout the breeding season in both years. This supports the hypothesis that most adult seabirds escaped the eruption, although many of their flightless young had perished. Successful breeding in post-eruption years was hindered, however, by loss of nesting habitat, which was buried in the eruption. By 2010, surface erosion had re-exposed small areas of potential crevice habitat and many species made some attempts to breed. Most breeding sites were ephemeral and quickly destroyed again by rapid erosion, so many breeding attempts ultimately failed and there appeared to be heavy competition for limited nest sites. With a pool of breeding adults surviving the eruption, recovery of the seabird colony at Kasatochi will likely depend on the pace of re-exposure and stabilization of former nesting habitat.

Short-term effects of the 2008 Kasatochi island eruption on marine birds and their at-sea habitats: Where do we go from here?

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Kasatochi Volcano, in the central-Aleutian chain, erupted on August 7th 2008. The resulting ash and pyroclastic flows blanketed the island, covering terrestrial habitats in 15-20 meters of material as well as depositing an unknown amount in nearshore marine habitats. We sampled the marine habitat near Kasatochi in 2009 to characterize the effects of the eruption on crested Auklets (*Aethia cristatella*) and Least Auklets (*Aethia pusilla*), the two most common marine birds that previously nested on Kasatochi. Analysis of SeaWiFS satellite imagery indicated that a large chlorophyll-a anomaly was the result of ash fertilization. Despite persistent erosion, we found no evidence of continuing marine fertilization from terrestrial runoff 10 months after the eruption. When compared to samples from 1996 and 2003, the distribution of accoustic biomass in 2009 showed little or no change in response to the 2008 eruption. Conversely, long-line sets at Kasatochi and two nearby islands in 1996, 2003 and 2009 suggested only Kasatochi suffered a dramatic decline in demersal fish following the eruption. At-sea surveys of marine predators in June 2009 established that crested and least auklets had returned to Kasatochi in relatively high numbers. Densities from July 2009 surveys were comparable to pre-eruption densities around Kasatochi. Neighboring Ulak and Koniuji islands showed higher variation in at-sea densities, but we found no evidence of a short-term eruption effect. Aside from nearshore habitats that were buried in ash, marine habitats in the Kasatochi area do not appear to show any lasting effects of the 2008 eruption. Continued at-sea assessments of the marine area around Kasatochi will be necessary to understand the long-term consequences of the eruption on these marine bird populations.

Movements and dive behavior of ribbon and spotted seals: evidence for niche partitioning in the Bering Sea

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Since 2007, 139 satellite telemetry tags have been deployed on ribbon and spotted seals within the central and western Bering Sea. The movements and dive behaviors recorded by these tags show evidence of niche partitioning between the two ice–associated seals. Movements of tagged spotted seals are mostly confined to the continental shelf and the majority of recorded dives are less than 90 meters with virtually no dives exceeding 200 meters. Ribbon seals range beyond the continental shelf and their dives are distributed over a wider range of depths with some dives exceeding 600 meters. During the critical breeding and molting period both species are strongly associated with sea-ice, their distributions overlap within the marginal ice zone, and they are known to have similar diets. However, we found that most spotted seal dives were to depths less than 70 meters while a much greater fraction of ribbon seal dives were deeper than 70 meters, and some deeper dives evidently occurred beyond the shelf break. Niche partitioning between ribbon and spotted seals has been previously theorized based on blood chemistries and diet studies, but this represents the first empirical evidence showing segregation during the critical breeding and molting period. These data provide important information about the diving capabilities of ribbon and spotted seals and are valuable for assessing how a changing environment may differentially impact these species.

Population structure as revealed by mtDNA and microsatellites in northern fur seals, *Callorhinus ursinus*, throughout their range

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The northern fur seal (*Callorhinus ursinus*; NFS) is a widely distributed pinniped that has been shown to exhibit a high degree of philopatry to islands, breeding areas on an island, and even to specific segments of breeding areas. This level of philopatry could conceivably lead to highly genetically divergent populations. However, northern fur seals have the potential for dispersal across large distances and have experienced repeated rapid population expansions following glacial retreat and the more recent cessation of intensive harvest pressure. Using microsatellite and mitochondrial loci, we examined population structure in NFS throughout their range. We found only weak population genetic structure among breeding islands including significant FST and ΦST values between eastern and western Pacific islands. We conclude that insufficient time since rapid population expansion events (both post glacial and following the cessation of intense harvest pressure) mixed with low levels of contemporary migration have resulted in an absence of genetic structure across the entire northern fur seal range.

Causes of mortality in northern fur seal (*Callorhinus ursinus*) pups, St. Paul Island, Alaska 1986-2010

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Northern fur seal (*Callorhinus ursinus*) pup production has been declining on an average of 5% for the last 20-25 years on St. Paul Island (57º15'N, 170º20'W), Alaska. To investigate this problem pre-weaned pups (n=3,129) were examined post-mortem from 1986 to 2010 on St. Paul Island, Alaska. Gross necropsy findings and histological lesions were used to determine cause of death. Five categories of mortality were identified: emaciation (57%), trauma (19%), perinatal mortality (18%), infectious diseases (3%) and miscellaneous causes (6%). The prevalence of perinatal mortality appeared to increase for the duration of this study and relative to past reports, whereas trauma and infectious conditions appeared to slightly decrease from 1986 to 2010. Although relatively stable during this investigation, emaciation was greater than reported for past studies. Over the last 35-40 years overall pup mortality has been estimated and the average overall percentage of pup mortality has varied from 5-10% which is considered to be extremely low for such a free ranging population of animals. Evidence was not found to implicate infectious diseases or on-land mortality regardless of the cause as a major factor in the general overall population decline in northern fur seals.

Steller sea lion foraging on Atka mackerel revealed by animal-borne video and data recorders

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Describing the foraging behavior of Steller sea lions (SSL, *Eumetopias jubatus*) is difficult due to the complexity of recording behavior while animals feed at depth. Many techniques have been developed in an attempt to infer how, when and where SSL forage, but visual confirmation of these inferences is essential for understanding foraging behavior. In an initial effort to obtain these data, five adult female SSL on the Lovushki Island rookery (Russian Kuril Islands) were outfitted with video and data recorders (VDRs) during the summers of 2008-09. A total of 717 individual dives were recorded during 14 separate foraging trips. Animals dove at a mean rate of 8.53 dives per hour, and dove to a mean depth of 55 m with a mean dive duration of 3.1 min. On average, 41% of each dive was spent near the benthos. The mean underwater swim speed for 511 dives was 1.98 m/s. Of the 717 dives, 49% (353) had accompanying video records. During these dives, a total of 495 prey encounters occurred, 261 (53%) of which resulted in successful prey captures. Ninety-eight percent (256) of all captures were of Atka mackerel (*Pleurogrammus monopterygius*). All dives were shorter than the mid-range cADL (calculated Aerobic Dive Limit) of 7.5 min (Richmond et al. 2006). Our results suggest that the food supply near Lovushki Island, a growing SSL population, is both readily available and plentiful enough to meet the nutritional needs of nursing females without requiring individuals to extend foraging dives beyond their ADL.

Institutional structure and profit maximization in the eastern Bering Sea fishery for Alaska pollock

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Walleye pollock (*Theragra chalcogramma*) is the largest whitefish fishery in the world and largest in U.S. by volume. The Alaska fishery has gross exvessel revenues of $300 million and a first wholesale value of over $1 billion. The market for U.S. pollock products has evolved significantly since the early 1990s, when U.S. pollock processors focused mainly on selling surimi and roe to Japan. The formation of harvesting cooperatives, resulting from the passage of the American Fisheries Act, has resulted in a complex suite of alternatives that includes increasing global markets and a diverse mix of product forms. Understanding how benefits of the fishery are distributed requires an understanding of international trade in pollock products. This paper reports on the development of an international market model for pollock products for 2000-2008, with a particular emphasis on surimi, fillets, and roe and their primary markets in the United States, Europe, and Japan. The simultaneous-equation equilibrium model included nine structural equations, with four allocation equations and five inverse demand equations. The model was fitted using a full information maximum likelihood systems estimator. Results conformed with theoretically anticipated relationships with respect to price, income, and substitution effects. Initial simulations indicate that that the first wholesale pollock revenues over fillets, surimi, and roe products are maximized at levels above the 2000- 2008 mean harvest level but below the maximum harvest of over 1.5 million mt in 2006. The model and its results will assist fishery managers in determining optimum yield for the fishery.

Design and operation of a novel flow-through seawater acidification system for Ocean Acidification research at the National Marine Fisheries Service Kodiak Laboratory

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Numerous agency and University laboratories are studying the effects of ocean acidification on biota. The goal of our acidification research is to conduct exposure experiments of CO_2 on larval, juvenile, and adult stages of king and Tanner crabs. To accomplish this goal a CO_2 delivery system capable of refined delivery of increased pCO_2 water was necessary. Published experimental designs use seawater treatments with CO_2 partial pressure (pCO_2) at equilibrium with present and Intergovernmental Panel on Climate Change projected atmospheric CO2 concentrations. Although many experimental laboratories are utilizing complex custom-designed gas-phase pCO_2-stat control systems to provide stable pCO_2 treatments, this project was to design a simple CO_2 delivery system capable of liquid phase pH control utilizing off-the-shelf modules. The system provides up to 20 l per minute of CO_2-augmented seawater to each of three treatments, with the option for thermal conditioning via chillers. Under control of a YSI pH controller, pure CO_2 gas is sparged into filtered seawater in a counter-current contactor connected to a storage tank to maintain roughly pH 5.5. This “super-acidified” seawater is blended with ambient seawater by Masterflex peristaltic pumps controlled by highly accurate Honeywell DuraFET pH controllers, and stored in each of the three treatment holding tanks. Water is then distributed to subject animal holding tanks. The system has excellent stability and minimal engineering intervention. This system will be reproduced at the Kodiak Laboratory to support a five pH by three temperature treatment system to better test the complexities of biological impacts of ocean acidification.

Estimating precipitation and temperature at high resolution in Alaska

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Monthly weather data have been generated on a high resolution grid (2 km by 2 km) for the state of Alaska. Climate data are a key component to quantifying freshwater runoff into the Gulf of Alaska. An understanding of this runoff is of value since it exerts partial control on the complex spatial and temporal patterns observed in nearshore Alaskan waters. The present study provides higher resolution weather data than have previously existed for this area. These data should further the understanding of freshwater runoff into Alaskan waters.

Proportional anomalies were calculated between monthly weather station data and long-term monthly climatic norms for each month between January of 1961 and December of 2009. Weather station data were obtained from the National Climatic Data Center (NCDC), and long-term monthly climatic norms were obtained from the PRISM (Paramater-Elevation-Regression on Independent Slopes Model) dataset. Calculated anomalies were then extrapolated over a grid covering the entire state. Finally, these anomalies were combined with the norms to provide monthly average temperature and cumulative precipitation over Alaska for all months between 1961 and 2009.

Preliminary results suggest significant interannual variability in temperature and precipitation. Results also agree with long-term precipitation and temperature norms. The highest precipitation generally occurs in September and October in the Chugach Mountains east of Prince William Sound. Warmest winter temperatures generally occur at low elevations near the Gulf of Alaska, and warmest summer temperatures generally occur in the interior of the state.

Developing and sustaining a real-time forecasting system for Prince William Sound

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After the successful Prince William Sound field experiment in July-August 2009, the WRF (Weather and Research Forecast) mesoscale atmospheric and ROMS (Regional Ocean Modeling System) oceanographic model have been running in real-time to provide 48-hour forecast on the daily basis. Forecasting the biogeochemical cycle and ecosystem is attempted with a NPZ model known as CoSiNE (Carbon, Silicate, and Nitrogen Ecosystem) coupled to the ROMS circulation model. The real-time model forecasts are provided to the Alaska Ocean Observing System (AOOS) for broader distributions. Several online tools have been developed to help users to analyze and visualize the WRF and ROMS output. This poster will also describe the reanalysis results from the 2009 field experiment.

Measuring the pulse of the Gulf of Alaska: oceanographic observations along Seward Line, 1997-2010

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The Seward Line in the Northern Gulf of Alaska has been the focus of multidisciplinary sampling for the past 13 years. Here we report on the observations of physical oceanography, nutrients, phytoplankton, and zooplankton over that period, with emphasis on the last year. In 2010, May temperatures returned to slightly above their long-term means, breaking the recent string of 3 cold years. Late summer temperatures were well above the September long-term mean. Consistent with water temperature, the spring bloom was of typical timing as were spring zooplankton communities. In contrast, the warms summer temperatures yielded low zooplankton biomass, with the communities within the Alaska Coastal current and Prince William Sound flooded by warm-water species originating from southern waters. Implications to higher trophic levels will be discussed.

Understanding marine biogeographic boundaries in the northern Gulf of Alaska

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Although the Gulf of Alaska has been identified as a marine biogeographic region, it is also the endpoint of ranges of many species of benthic marine algae. Benthic marine algae are excellent indicators of environmental conditions because of their sedentary habit and limited dispersability. Many southern species reach their (north)western limit in the Kodiak archipelago in the western Gulf of Alaska. These include species ranging from the culturally important *Porphyra abbottiae* to several species of kelps (*Macrocystis pyrifera*, *Lessoniopsis littoralis*, *Pleurophycus gardneri*) to some less conspicuous species such as *Cryptopleura ruprechtiana*, *Nemalion helminthoides*, *Porphyra papenfussia*, *Porphyra perforata*, and *Serraticardia macmillanii* among others. At the same time, other species reach their eastern limit in the northern Gulf of Alaska, often in the Cook Inlet area. These include the green alga *Acrosiphonia cartilaginea*, the kelp *Agarum turneri*, and red algae such as several undescribed species of *Halosaccion*, an undescribed species of *Palmaria*, a new genus related to *Halosaccion*, *Mastocarpus pacificus* and possibly *Porphyra variegata* among others. Although most of these species are recognizable by their distinctive morphologies or habitats, the identities of others have only been verified using molecular sequencing. Future studies are aimed at determining whether physical or biological factors are responsible for these ranges limits and what these physical and biological factors are.

Temporal and Spatial Variability in the Partitioning and Flux of Riverine Iron Delivered to the Gulf of Alaska

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Iron (Fe) is a micronutrient that is thought to limit phytoplankton productivity in offshore waters of the Gulf of Alaska (GoA). However, it has been proposed that in coastal regions where offshore, Fe-limited, nitrate-rich waters mix with relatively Fe-rich river plumes, productive ecosystems and fisheries result. Indeed, an observed northward increase in phytoplankton biomass along the pacific coast of North America has been attributed to higher input of riverine Fe to coastal waters, suggesting that many of the coastal ecosystems of the North Pacific rely heavily on this input of Fe as a nutrient source. Based on our studies of the Copper River (the largest point source of freshwater to the GoA) and its tributaries, it is clear that riverine Fe delivered to the GoA is primarily derived from fine glacial flour generated by glacial weathering, which imparts a unique partitioning of Fe species and Fe size fractionation in coastal river plumes. Furthermore, the distribution of Fe species and size fractionation exhibits significant seasonal and spatial variability based on the source of iron within the watershed, which varies from glacial mechanical weathering of bedrock to internal chemical processing in portions of watersheds with forest and wetland land covers. These findings are relevant to our understanding of the GoA biogeochemical system as it exists today and can help to predict how the system may evolve as glaciers within the GoA watershed continue to recede.

E**xploring Ecological Change in Cook Inlet Beluga Whale Habitat through Traditional & Local Ecological Knowledge**

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The Cook Inlet beluga whale, one of five Alaskan stocks, is genetically distinct and geographically isolated from other populations. Historically, Cook Inlet whales were hunted commercially, for sport, and for subsistence uses. The Marine Mammal Protection Act (MMPA) of 1972 ended commercial and sport hunting; in 1999, subsistence hunting voluntarily ended. In 2008, Cook Inlet beluga whales were listed as endangered under the Endangered Species Act after annual aerial surveys indicated the population was not recovering as expected. A combination of natural and anthropogenic factors may be affecting this population's recovery. This study documented traditional and local ecological knowledge of Alaska Native subsistence hunters and fishers and commercial fishers through participatory research to explore ecological changes in Cook Inlet over time and to identify potential factors impacting this beluga whale population. Study results identified potential environmental and climate change factors including prey competition, health of beluga and their prey, and the presence of killer whales, the majority of which may indicate an ecosystem regime shift in the Cook Inlet region. Human-related factors included fisheries management and related prey reduction, water contamination, and anthropogenic-related noise. These results corroborate identified threats to beluga whales and also identify potential new areas of scientific investigation and management. As such this study demonstrates the value of incorporating traditional and local ecological knowledge into ongoing science and management.

A Method to Estimate Regional Natural Conditions for Trace Metals in Marine Sediments of Southcentral Alaska's Coastal Regions

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Alaska's 40,000 km coastline remains relatively untouched by direct pollution, although hydrocarbon and mineral resource extraction and vessel wastewater discharges are increasing along the coastline. Sediments provide an integrated long-term signal for naturally occurring and anthropogenic chemicals—in this case, trace metals—in contrast to repeated water measurements, which can be highly variable. Establishment of sediment chemical in this case, trace metals natural conditions, is critical to detecting, understanding, and managing future environmental changes. Knowledge of natural conditions helps identify and place in context regional patterns of contamination. Natural condition values for sediment trace metals are assessed against risk-effects-based screening Effects Range Low and Effects Range Median values. Alaska can use its coastline's almost pristine condition to establish regional natural conditions for sediment trace metals. Natural conditions are based on the population distribution of the trace metals, which incorporates variations in grain size, trace and major elements, and total organic carbon. For As, Cr, Cu, Pb, Hg, Ni, and Zn, regional Southcentral Alaska sediment trace metal natural conditions based on probabilistic survey population estimates are developed.

ShoreZone Mapping in Alaska, British Columbia, and Washington

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ShoreZone is a coastal marine habitat mapping system, in which spatially referenced aerial imagery is collected specifically for classification. The resulting mapped dataset includes imagery with geomorphic and biological attributes as a searchable geospatial dataset of coastal habitat features. The imagery provides a useful baseline and visual reference. The mapped features include: shoreline morphology, substrates, and biotic resources such as eelgrass, canopy kelps, salt marshes and other habitat descriptors. The many data applications include: oil spill contingency planning, conservation planning, habitat research and other coastal site evaluations.

Approximately 92,500 km of ShoreZone imagery exists for the Pacific Northwest coastline including the entire shoreline of Washington (5,000 km), British Columbia (40,000 km), and ~47,500 km of the Alaskan coast. The project is on-going with ~27,900 km of Alaska coastline left to be imaged and two aerial surveys are currently planned on the Alaska Peninsula in 2011. The Alaska imagery can be viewed online at http://www.fakr.noaa.gov/habitat/shorezone/szintro.htm.

The ShoreZone program is built on a foundation of funding and contributing partners, including state and federal governmental agencies, nonprofit organizations, spill response planners, and industry, as well as other scientists and spatial data specialists. The multi-agency program provides a framework to build on and supports a contiguous, integrated coastal resource database that extends from the mouth of the Columbia River, through British Columbia, the Gulf of Alaska, Bristol Bay, and northwards to the Arctic coast.

Spatial Patterns in the Distribution and Abundance of Benthic Intertidal Species in Glacier Bay National Park and Preserve, Alaska, and their Relationship to Glacial Chronology

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The distribution and abundance of intertidal species within Glacier Bay National Park and Preserve, Alaska, were investigated during development of a rocky intertidal monitoring protocol. Glacier Bay proper, the area of focus, was ice-filled approximately 230 years ago. Since then, glacial recession has influenced oceanographic patterns that vary along the axis of recession within the bay and created marine habitats of varying age. During the sampling design process, 25 rocky sites were randomly selected as characterizing the defined habitat type within the bay, which has a 1,109-km coastline. Quantitative sampling of these sites during 1997-2001 has created an extensive dataset of species distributions and abundances. Patterns in these distributions indicate increasing species richness with distance from glaciers and varying patterns in the relative abundances of species. Factors influencing these patterns will be discussed.

Evaluation of the Southwest Alaska Network Nearshore Monitoring Program: Synthesis, analysis, and insight from the first 5-years

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The SWAN Nearshore Monitoring Program measures over 50 biological, chemical, and physical metrics encompassed within six SWAN I&M designated vital signs. The sampling design incorporates well-known ecological interactions and processes primarily within the nearshore food web, at spatially balanced, randomly selected sites within the coastal network of Parks in Alaska. To date, we have complete 5-year data sets for approximately half of the metrics. Because of the holistic nature of the design, we can now utilize existing data sets to evaluate several aspects of the program. While we are interested in what the data are telling us about ecosystem processes, we will also evaluate the functionality of the program. For each metric we will determine whether current sampling intensity and frequency are sufficient to detect change and whether sampling frequency can be reduced, thus allowing us to minimize costs. We will incorporate results in sampling protocols to optimize our ability to detect trends for the nearshore vital signs.

Contaminant exposure to young polar bears

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Many toxicological studies identify young as the predominant cohort of concern for toxicant effects. Unfortunately, this cohort is often under represented in wildlife studies. We collected milk from lactating polar bears to examine the magnitude and variation of the maternal transfer of Hg and PCBs to young polar bears in relation to select biological factors. Polar bear milk contained 5.8 to 71.8 ng / g ww of Hg and 160 to 690 ng / g ww (547 to 5190 ng / g lw) of ΣPCB11. Congener PCB153 was most abundant followed by PCB180, PCB99, PCB138, PCB170, PCB118, and PCB194. Milk contained 5 to 30% lipid and lipids in milk were predominantly triglycerides Concentrations of ΣPCB11 correlated with concentrations of lipids, but negatively related to concentrations of Hg. Female polar bears with > 20% lipid content of milk, but low concentrations of milk ΣPCB11, were generally older (14.4 ± 4.9 yrs versus 10.3 ± 2.9 yrs) and within the Chukchi Sea sub-population. The percent lipid content and concentrations of ΣPCB11 in polar bear milk did not differ by number of cubs (1, 2) or age of cubs (cubs of the year, yearling, 2 year old). These data are the first reported values of toxicants, stable isotope values, and lipids in samples of polar bear milk in the Southern Beaufort Sea and Chukchi Sea sub-populations. Furthermore, this is the first report of Hg concentrations in polar bear milk from any region. These data provide a unique insight into the concentration and dynamics of contaminant exposure to dependent young.

Online Database of ShoreZone Shore Stations Launched

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The Shore Station database is an interactive spatial dataset providing intertidal biophysical data from sites throughout the Gulf of Alaska. The purpose of this dataset is to provide users of ShoreZone with additional information on the regional differences of intertidal communities found in Alaska. Over 400 sites have been documented since 2002. These on-the-ground data record species occurrence, as well as their associated biobands, and describe across-shore profiles and substrate characteristics.

The Shore Station database is accessible online under “Related Databases” on the main ShoreZone website (www.alaskafisheries.noaa.gov/maps). The website interface guides the viewer through spatial searches by region, locale, station, bioband or species of flora and/or fauna. Query results can be downloaded as spreadsheet files, including species lists resulting from searches by region or by station. Station photos are captioned and viewable as slide show for each station and can be downloaded to your desktop. Detailed diagrams of beach profiles showing slope, length, substrate and biota are also viewable. Supplemental information including tutorials, definitions of ShoreZone attributes, and links to species descriptions (www.seaweedsofalaska.com) are also integrated into this website.

Development of the online ShoreZone Shore Station database was funded through a partnership between Cook Inlet Regional Citizens Advisory Council, NOAA Fisheries, and Archipelago Marine Research Ltd.

Locating acoustic-tagged fishes and describing their environment using an autonomous underwater vehicle

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We tested the feasibility of using an innovative system for detecting acoustic-tagged fishes and examining the effects of the marine environment on tag detection. This fish tracking system consisted of hydrophone receivers mounted on an autonomous underwater vehicle, the Webb Slocum glider. Acoustic tags were attached to a stationary buoy line at five different depths in Auke Bay, Alaska and the glider made repeat transects past the buoy. During these transects, the glider also collected a high resolution suite of environmental measurements including temperature, salinity, pressure (depth), distance to bottom, chlorophyll fluorescence, turbidity, and dissolved organic matter fluorescence. The hydrophones mounted on the glider recorded up to 150 detections per tag in a single pass of the glider throughout the strongly stratified water column. Maximum detection range of the tags was approximately 600 m, although the vast majority of detections were recorded from <300 m. These results indicate that this system represents a new, interdisciplinary tool for detection of multiple acoustic-tagged fish over monthly time scales, simultaneous with the collection of high-resolution biophysical oceanographic data from the fishes’ habitat.

Salinity and irradiance effects on growth and maximum quantum yield of photosynthesis of sub-Arctic sugar kelp (*Saccharina latissima*)

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In sub-Arctic regions, accelerated melting of glaciers creates stressful environmental conditions, e.g., reduced salinity and irradiance, in coastal ecosystems such as kelp beds. Our goal was to determine how these stresses affect juveniles of the kelp *Saccharina latissima* originating from two environmentally distinct shores, one under oceanic and one under estuarine, glacial influence. Laboratory tests assessed the effects of varying salinities and irradiances on growth and maximum quantum yield (Fv/Fm) of photosystem II of *S. latissima*. A reciprocal shore transplant study examined seasonal growth patterns *of S. latissima*. Overall, growth rates decreased with decreased salinity and irradiance. Growth rates of juveniles from the glacially-influenced shore were significantly lower than those of the oceanic shore at most salinity and irradiance treatments. Our results suggest that *S. latissima* exhibit phenotypic plasticity in their growth responses, which seems to be constrained within specific seasonal growth patterns in accordance with their environment of origin. Juveniles from both shores grew negligibly at salinities below 13 and irradiance of 5 µmol photons m^{-2} s^{-1}. They also exhibited reduced Fv/Fm at a salinity of 10, but Fv/Fm was not affected by decreased light levels. *Saccharina latissima* proved to be relatively tolerant and adaptable to reduced salinities and irradiance, but there are limits to their resilience.

A comparison of zooplankton time series from Prince William Sound and the Gulf of Alaska

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Herring from Prince William Sound feed on zooplankton, some originating within the Sound and some from the Gulf of Alaska (GOA) introduced to PWS via a variety of processes. Additionally, adult herring almost certainly forage outside of the Sound, feeding on zooplankton over the wider Alaskan shelf. Understanding the sources of variability in the herring forage base is essential to efforts to understand the herring recovery process and to address basic resource management questions. Direct measurements inside PWS do not explain how the interannual variation in ocean food sources creates interannual variability in PWS zooplankton, nor when changes in ocean zooplankton are to be seen inside PWS. Correlations between the offshore and PWS zooplankton may be complex so that the ocean carbon signal in PWS in any one year is the result of unequal effects from several years of GOA inputs. Work is now beginning to address this issue using a time series of seasonal zooplankton data (2000 to present), collected by the Continuous Plankton Recorder (CPR), from the Alaskan shelf and northern oceanic GOA. This survey has been maintained through support from a variety of agencies including the EVOS TC and the NPRB. Zooplankton net samples were also collected at several sites within PWS between 2000 and 2006 and again from 2010 onwards under separate EVOS TC funded projects. This presentation will describe the data collected and progress to date on intercomparisons.

The effect of environmental variables on the short range movement of the giant Pacific octopus

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In Prince William Sound, Alaska, nine octopuses were acoustically tracked from mid May 2009 until mid October 2009. Locations were determined using a hyperbolic positioning system. Three males and six females ranging from .53 to 7.2 kg were tracked for between 1 and 31 days each during the course of the study. Movements were categorized as loop, indirect, and directed movements: loop movements correspond to foraging (Mather 1991); directed movements to relocation; indirect movements were uncertain but may represent foraging. Octopuses showed two distinctive periods of activity ($p = .00$) with increased activity at night, reinforcing previous understanding that octopuses are nocturnal. Results suggest that this nocturnal activity is not daily but occurs once every 48-72 hours. Timing of octopus movement is also related to tidal level in the intertidal, as octopuses in the intertidal move during significantly higher tides than octopuses in the subtidal ($p=.01$). Data support a continually shifting center of area use as octopuses move from den-to-den with a leveling off of area use once each den is established.

Variation in mesozooplankton abundance around Kenai Peninsula from May-August 2010

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Marine mesozooplankton are an important part of the trophic system in Alaskan coastal waters. As a segment of the marine ecosystem they can be affected by changes in water quality. Mesozooplankton samples were collected using a 335µm mesh ring net at three beach locations in Southcentral Alaska: Kenai, Homer and Seward in May, July and August 2010. Environmental measurements of pH, salinity and temperature were collected at the time of net sampling. All samples were investigated under a microscope to identify classes present and count the number of individuals in each sample and apportion them to appropriate taxon level. Relationships between pH, salinity, temperature, and class abundances during the course of the study were investigated using multivariate analysis of variance (MANOVA). Relative abundances of mesozooplankton found in these coastal waters varied during the surveyed period. A total of eighteen classes were identified. There were more individuals per sample collected during May than in August. *Thecosomata* comprised 49.3% of individuals in the samples in May, but only 6.7% in August. *Calanoida* were 37% of the sample in May, but only 2% in August. The seasonal changes in mesozooplankton abundance could be part of the seasonal species succession, or they could be the result of the influence of environmental factors on their reproductive and somatic growth. An understanding of the seasonal changes in pH, salinity and temperature in coastal waters can help explain some of the trophic dynamics in this Alaskan ecosystem.

Seasonal Changes in Productivity in the Copper River Plume and Coastal Gulf of Alaska

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The Copper River is the largest point source of fresh water to the northern Gulf of Alaska, but the hydrography, biogeochemistry, and biology of the region are not well described. Oceanographic surveys were conducted in April, May, June and July 2010, along a transect line stretching from the mouth of the Copper River, across the plume, to well past the shelf break. In April, the water column was well mixed, with a very low freshwater signal nearshore; phytoplankton biomass was low, and macronutrient (nitrate, silicate, and phosphate) concentrations were high. The zooplankton was dominated by relatively scarce small bodied copepods inshore, and large pteropods and abundant large bodied copepods (*Neocalanus* sp.) offshore. By early May, weak temperature and salinity stratification were present, and phytoplankton biomass had increased, while nutrients showed indications of being drawn down. Although the spring bloom was at an early stage, phytoplankton biomass and nutrient drawdown were more pronounced onshore, indicating an earlier onset to production in the near shore region. Zooplankton abundance was low, and was mostly small bodied copepods and early stages of *Neocalanus*. By June, the spring bloom was completed, and all nutrients were depleted in the surface water, except for silicate, which was elevated in the less saline water in the vicinity of the plume. Small bodied copepods dominated the plankton at all stations, and small pteropods were abundant offshore. Surface trawls for forage fish along the transect line caught none in April and gravid Eulachon were collected near shore in May. Juvenile salmon (primarily coho and sockeye) and herring were collected in June, and abundances were low near shore, largest immediately at the river plume front, and smallest offshore of the front. No salmon were caught in July, and large numbers of stickleback were captured at the shelf break.

Fecundity of the euphausiid *Euphausia pacifica* from the North Pacific with a focus on the northern California Current and the Gulf of Alaska

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Euphausia pacifica is an important secondary producer in many oceanic and coastal ecosystems ranging throughout the North Pacific including the Gulf of Alaska and deeper waters of the Bering Sea. It is a key grazer on phytoplankton and a major prey item for many upper trophic level species, including most commercially harvested fish such as salmon, pollock, herring, and rockfish, as well as seabirds, and whales. This project sought to improve upon the current knowledge of reproductive rates for *E. pacifica* from the Gulf of Alaska by exploring the range of reproductive behaviors exhibited by individual females maintained over several months in a controlled laboratory setting and thereby allow for direct comparison to other populations maintained in the same setting. Ultimately this has not been possible as originally designed due to multiple unsuccessful attempts to collect gravid females from the Gulf of Alaska. In lieu of the planned work, we present long term fecundity comparisons carried out in our laboratory between the population from the shelf break off central Oregon to populations from Southern California, the Washington shelf, and a deep station in the relatively oligotrophic sub-arctic extension of the North Pacific gyre 324 km west of Newport, Oregon. We also show a compilation and analysis of *E. pacifica* brood size data from 8 geographic regions around the North Pacific. These results help to place the existing data from Alaska (Pinchuk and Hopcroft 2006) in the context of all known reproductive rates and strategies for *E. pacifica*.

Interannual Variability of *Neocalanus flemingeri* and *N. plumchrus* in Shelikof Strait, Alaska

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The copepod species *Neocalanus flemingeri* and *N. plumchrus* are nutrient-rich prey for fish, seabirds and marine mammals in the Gulf of Alaska ecosystem. However, little is known about how these species seasonally overlap in this region, especially in the western Gulf of Alaska. Species and stage composition were analyzed from one station in Shelikof Strait, Alaska during the first week of May for eight years between 1985-2001. *Neocalanus flemingeri* was statistically more abundant than *N. plumchrus* among the years analyzed (p=.002). In general, the abundance of both species decreased after the regime shifted to warmer conditions in 1989 and to cooler conditions in 1998. The abundance of both species increased during the time period between the regime shifts. There was also a significant difference in the proportion of CIV and CV copepodites for *Neocalanus plumchrus* (p=.025), but not for *N. flemingeri* (p=.529). There was no evidence from stage composition data that indicated an annual trend in development as observed for Ocean Station Papa and the Vancouver Island continental margin. There was a single anomalous year, 1996, which had a higher abundance of *Neocalanus* plumchrus stage CV than all other years, and this occurred during a year when there were higher than average sea surface temperatures upstream of the study area in the northern Gulf at GAK1. More comprehensive sampling is needed in this region to better examine seasonal and annual trends in *Neocalanus* speciation and development.

Characterization of the Organisms Which Cause Paralytic Shellfish Poisoning in SE Alaskan Waters

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Paralytic Shellfish Poisoning (PSP) represents a significant public health threat in Alaska. It causes serious human illness with occasional mortalities and can also adversely affect marine mammals. PSP is caused by the bioaccumulation of potent neurotoxins (saxitoxins) by both shellfish and crabs. The actual sources of the various PSP toxins are microalgae in the genus *Alexandrium*. These toxins enter the food chain via a variety of filter feeding organisms including clams and mussels. Currently there is no way to effectively screen for PSP toxins over the vast coastline of Alaska. In addition, very little is known about the diversity and ecology of Alexandrium species in Alaska. Consequently, public health officials have taken the prudent approach of banning shellfish harvests in most areas of Alaska. Unfortunately, this leads to extensive shellfish resources being vastly under-utilized, particularly as a subsistence food source. The purpose of our current project is to genetically characterize the diversity of *Alexandrium* species in Alaska and to establish cultures and determine which species are producing toxins. The resulting genetic data will be used to develop qPCR assays which can be used by mangers and researchers to monitor for the distribution and abundance of toxic species. That information can in turn be used to determine which conditions most favor toxic blooms and to assess whether some areas are more likely to become toxic than others. This project is in its initiation phase and preliminary results obtained to date will be presented.

Using remote sensing to assess behavioral responses to pot-fishing in Alaskan octopuses

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Octopuses are often caught as by-catch in Alaskan waters including pot-fisheries directed for crab and cod, long-line fisheries, and bottom trawls. An understanding of how octopuses may be attracted to pot-fishing gear and interactions with such gear is essential to provide a biological basis required for fisheries management. A total of 15 octopuses were tracked within Eldred Passage in Kachemak Bay, Alaska from mid September 2010 until mid November 2010. Octopus locations were obtained using a non-real-time underwater acoustic fine-scale positioning system. Movements were tracked (1) in the absence of pot gear, (2) with the introduction of pot gear (Tanner crab pots), and (3) in response to relocation of pot gear versus resetting of pot gear in a single location. Preliminary results describe octopus movements during these three portions of the study.

Metabolic Consequencecs of *Hematodinium* infection in Tanner crab from Southeast Alaska

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Bitter crab syndrome (BCS) is a disease that affects many commercially important crabs and is caused by the dinoflagellate parasite *Hematodinium* sp. There is a high incidence of the BCS in Tanner crabs *Chionoecetes bairdi* from southeastern Alaska. In sampled regions, 100% of primiparous females are infected. We have the opportunity to collect infected and uninfected crabs from the wild and analyze metabolic changes as they occur from early to late stages of the disease. Multiparous, and primiparous female *C. bairdi* were collected near Auke Bay, Alaska and at the University of Alaska Southeast Marine Laboratory. An uninfected group of crabs was collected in Icy Straight, AK. Hemolymph was sampled weekly for histological visualization of *Hematodinium*, and for measurement of glucose. Metabolic rates were measure for primiparous, multiparous and juvenile crabs and results will be presented. Histological changes of the parasite occurred in all of the infected crabs as the disease progressed through the motile dinospore stage. Infected females hosted either macrodinospores or microdinospores, and all females died from the disease either soon after or just prior to sporulation. Circulating glucose was measured in healthy and diseased crabs and were significantly lower in infected crabs when compared to uninfected crabs (6.4 ± 2.3 mg/dl compared to 12.2 ± 4.2 mg/dl). Circulating glucose decreased to non-detectable levels at later stages of the disease. Eyestalk ablation, a technique that removes the hyperglycemic hormone and normally decreases circulating glucose in crustaceans was not able to decrease glucose further in infected crabs.

Population Structure of the Giant Pacific octopus (*Enteroctopus dofleini*) in South Central Alaska

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Recent legislation has mandated that the National Oceanic and Atmosphere Administration (NOAA) designate over-fishing limits for the giant Pacific octopus, *Enteroctopus dofleini*. This large species of octopus is commonly captured as by-catch in Pacific cod and other pot fisheries in Federal and State waters around Alaska. Enforcing an overfishing limit on octopuses has the potential to close these valuable commercial fisheries before target species limits are reached. There are currently insufficient data available to designate biologically relevant populations of octopuses for purposes of management. This is because the population structure of the giant Pacific octopus is unresolved. Lack of clarity about the relationships among populations of *E. dofleini*, coupled with large variation in morphological and behavioral characteristics, has resulted in multiple, controversial proposals about multiple subspecies and possibly species occupying the North Pacific rim. This project would provide genetically based descriptions of population structure through an analyses of mitochondrial and microsatellite DNA extracted from tissue samples collected from Prince William Sound, Resurrection Bay, and Kachemak Bay, Alaska (USA). Such data are needed to identify biologically relevant management units. This project will apply two marker systems (maternally-inherited organelle mitochondrial (mtDNA) and autosomal nuclear microsatellite DNA) to examine species' status and analyze population-level structure within south central Alaska waters. There are benefits to using both marker systems: mtDNA sequence information is useful for phylogenetic reconstructions at the level of species and subspecies, but can also be applied to population genetics questions; while microsatellite sequence information is helpful in resolving more microgeographic population structure.

Assessment of contaminant body burdens and histopathology of fish and shellfish species frequently used for subsistence food by Chugach Alaska Native communities

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Pollution and other environmental factors such as climate change constitute stressors that are impacting the health of marine and coastal resources in Alaska. Subsistence food may constitute a health concern in rural Alaska because community members often rely on fish and wildlife resources not routinely monitored for persistent bioaccumulative contaminants and pathogens. Subsistence activities are a large part of the traditional culture, as well as a means of providing protein for Tribal members. In response to the growing concerns among Chugach communities, contaminant body burden and histopathology condition of two species of salmon (*Oncorhynchus keta* and *Oncorhynchus nerka*) and shellfish (*Clinocardium nuttallii* and *Mya arenaria*) are being assessed. The fish and shellfish were collected from traditional subsistence harvest areas in the vicinity of Nanwalek, Port Graham and Seldovia, AK, and are being analyzed for trace metals and residues of organic contaminants routinely monitored by the NOAA National Status & Trends Program (NS&T). Additionally, the fish and shellfish are being histologically characterized for the presence, prevalence and severity of tissue pathology, disease, and parasite infection. The aim of this study is to provide reliable chemistry and histopathology data and information for local resource managers and Alaska Native people regarding subsistence fish and shellfish use and management needs.

Acoustic repertoire of Pacific cod (*Gadus macrocephalus*): Does it have one?

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Many fish species commonly produce knocks, grunts, and pulsed sounds. Atlantic cod (*Gadus morhua*) produce grunting sounds and knocks in captivity and in the wild; however no sound production by Pacific cod (*Gadus macrocephalus*) has been reported previously. To determine if Pacific cod produce sounds, passive acoustic recordings and behavioral observations were collected during June and July 2010 at the Alaska SeaLife Center in Seward, Alaska. The “Deep Gulf” tank, where recordings were collected, contained eight Pacific cod, a Pacific halibut (*Hippoglossus stenolepsis*), three Sablefish (*Anoplopoma fimbria*), three Great sculpins (*Myoxocephalus polacanthocephalus*), a Plain sculpin (*M. jaok*), three Yellow irish lords (*Hemilepidotus jordani*), four Longnose skates (*Raja rhina*), two Lingcod (*Ophiodon elongatus*), a Giant wrymouth (*Delolepis gigantean*), and four Flat bottom stars (*Asteria amurensis*). Passive acoustic data were collected using a HTI-96-MIN hydrophone (response up to 30 kHz) and a handheld digital recorder Edirol R-09. Video data were collected using an 8GB Flip Video Ultra HD camcorder. In over 48 hours of recordings, a total of six distinct, likely fish sounds were found. All sounds were single pulses, ranging in frequency from 154-440 Hz and lasting <190 ms. Three different Pacific cod behaviors were observed: yawning, milling, and feeding. Our findings are inconclusive on whether Pacific cod is the source of these sounds; since rockfish and sculpins produce sounds in similar frequency range and duration. Further study is necessary for conclusive coupling of recorded sounds with individual species. Understanding the acoustic repertoire of these species could aid in population monitoring.

Effects of ocean acidification on larval development in Alaska Tanner crabs (*Chionoecetes bairdi*)

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The goal of this study is to measure the effects of ocean acidification on larval development and mortality in Tanner crabs, *Chionoecetes bairdi*, in Kachemak Bay, Alaska. The Tanner crab population of Kachemak Bay once supported a commercial fishery, but severe stock declines forced closure of the fishery in 1995. An additional potential threat to the population has just been recognized: A decrease of up to 0.4 pH units is expected to occur in high-latitude waters of North America in the next century. Such a decrease, combined with elevated water temperatures, could prove to be detrimental to *C. bairdi* by causing augmented rates of mortality and abnormal development of stage I and II zoea. Detrimental effects of ocean acidification have already been demonstrated in a number of taxa, including several crustaceans. Here, it is hypothesized that increasing acidity will cause increased mortality and frequency of abnormal development in larval Tanner crabs. Larvae from several ovigerous females captured in Kachemak Bay will be raised in flow-through seawater tanks at the Kasitsna Bay Lab. There will be three pH treatments: pH as measured in Kachemak Bay in May 2011, pH expected for the year 2050 and pH expected for the year 2100. Each week, for the duration of the two zoeal stages, mortality, carapace length and larval weight will be measured. In addition, the impacts of water acidification on exoskeleton mineralogy will be assessed by measuring the calcium and magnesium content of the shell.

The response of juvenile walleye pollock (*Theragra chalcogramma*) to projected increases in ocean acidification

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With rising atmospheric CO_2, ocean pH is predicted to decrease 0.3 to 0.5 units by 2100. Several biological consequences of ocean acidification across this range have already been documented in invertebrates, including decreased calcification rates and coral bleaching. However, there have been comparatively few studies that focus on marine teleosts' response to decreasing environmental pH. As walleye pollock (*Theragra chalcogramma*) are a significant marine resource to commercial fisheries and ecosystem dynamics, it is crucial to understand how this species will respond to changing ocean conditions. Wild caught juvenile walleye pollock (age 1+) were reared at current ocean conditions and three pH treatment levels (7.9, 7.6, and 7.2) to match projected levels. After the six week exposure period, their physiological response was assessed using a suite of bioindicators. Marked differences were observed in several blood gas parameters. Bicarbonate concentrations increased from 9.72 mmol/L at pH 8.05 to 15.07 mmol/L at pH 7.2. Blood pCO2 also increased from 38.39 mmHg to 46.38 mmHg over the same interval. There was no overall response pertaining to indicators of stress (blood cortisol, cortisol secretion, blood glucose, hematocrit), tissue damage (lactate dehydrogenase, alanine transaminase, aspartate transaminase), or whole body indices (body condition, hepatosomatic index, growth rates). Overall, these results indicate that walleye pollock are able to acclimate to different environmental conditions, and the experimental conditions were within their physiological tolerance window. However, it remains unknown whether chronic exposure will have long term effects on walleye pollock, or how early life history stages will be affected.

Electronic Tagging in a Light Limited World

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For species of fish that spend most of their time at depths greater than electronic tags' capabilities of sensing light, what can we rely on? The Earth! It's been suggested that coupling geomagnetic data with light data can improve the accuracy of electronic tags at high latitudes such as Alaska.

Initial tagging studies prove this hypothesis as accurate throughout most parts of the world. Tagging studies in California, Florida, Australia, and Northern Europe have shown accuracy in latitude on average to be 35nm and longitude on average to be 34nm using the SeaTag-GEO.

Electronic tags are challenged in the Alaskan environment in all times of the year due to the day lengths. Furthermore, Pacific halibut (for example) put tags to the test with their diving behavior and the waters that they thrive in. At depth, light attenuation is generally too great to determine latitude and longitude effectively and while in turbid water the situation is quite similar or worse.

SeaTag tags are equipped with a 3-axis magnetometer and a solar cell which acts as a light sensor. There are two distinct advantages to this approach: light independent latitude positioning and a larger light sensor.

This talk will discuss the possibility of using geomagnetics as an alternative to light-only tags. It will discuss the advantages and disadvantages. Finally, the talk will show some preliminary test data from Alaska proving the hypothesis that using magnetic can improve the overall positioning at high latitudes.

Application of an adaptive acoustic/trawl survey to reduce uncertainty in rockfish biomass estimates

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Survey biomass estimates of several Alaskan rockfish species have shown large interannual variations that are not consistent with their longevity. These variations can be attributed to "patchiness" of the spatial distribution of the population, which results in estimation error when high-density patches are disproportionately represented in survey trawls. We evaluate the performance of an experimental survey design to reduce the variability in estimated biomass for patchily-distributed Pacific ocean perch. The design is a variant of adaptive sampling and uses acoustic information to distinguish areas of higher density fish concentration from background areas of lower concentration. In addition to the pre-planned trawl stations specified before the cruise, trawl tows are conducted in the high density fish areas identified during the cruise. The results will help identify whether an adaptive sampling design is a feasible approach to address high survey variability. An analysis of previously recorded echosign data produced an algorithm for delineating a "patch". In 2009, we conducted a 12 day pilot survey near Yakutat, AK to test the sampling design. Fifty-nine trawl hauls were completed, with 19 "patch" stations and 40 background stations. Mean catch-per-unit effort of Pacific ocean perch in "patch" stations was 42,540 kg/km^2 and 7,540 kg/km^2 in background stations. We compare estimators, and examine alternative patch definitions. We show school detection results from Echoview compared to our patch-detecting algorithm. The results showed that rockfish schools may be more ephemeral than previously thought. Additionally, we suggest improvements to the sampling design based on our fieldwork.

Habitat Equivalency Analysis (HEA): A tool for assessing marine impacts and mitigation requirements – the Sitka Airport Example

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Although several widely used approaches exist to assess function (quality) of freshwater wetlands, no such approach is available in the marine environment. A method was needed to assess ecological functions of marine habitats impacted by planned safety expansion of the Sitka Airport. Project fill would eliminate 8.9 acres of marine habitat and alter the nature of 9.4 additional acres. We worked with permitting agencies to generate consensus to use an innovative application of the Habitat Equivalency Analysis (HEA) model to define project marine impacts and to evaluate alternative mitigation actions. The HEA model was developed by NOAA to assess the mitigation required to replace marine ecological functions and services lost due to an injury or impact.

We began with an inventory of habitat types that would be impacted and developed a matrix to rate (0 to 10) the degree to which each habitat type provides a suite of ecological functions. This "relative habitat function" for each habitat, times its area, was used to calculate project losses and gains in units of Habitat Functional Acres (HFA). Net present value of habitat in units of Discounted Functional Acre Years (DFAYs) was then calculated using actuarial principles of economic theory. The DFAY "debit" calculated for the project reflected temporal losses in habitat function, and the time to achieve full function of altered habitats. DFAYs lost to project construction (and gained from recolonization of newly placed rock surfaces) determined the net amount of mitigation needed to compensate for lost ecological functions of impacted marine habitat.

After calculating DFAYs lost to airport expansion, we identified a suite of potential habitat protection, restoration, and enhancement actions within Sitka Sound that would compensate for some or all of the losses of marine habitat. Finally, we used HEA to determine the effectiveness of the selected mitigation action in compensating for (replacing or protecting) those functions that would be lost. The objective of compensatory mitigation was met with this approach when the number of DFAYs provided by the mitigation action(s) equaled or exceeded the number of DFAYs lost.

Estimating over-winter mortality of age-0 Pacific herring based on loss of energy and implications for recruitment

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A winter mortality model based on empirical mortality and energy levels following forced fasting was applied to age-0 Pacific herring of Prince William Sound, Alaska. Energy levels measured during November 2007, 2008, and 2009 were used as model initial conditions. Observed energy values in March 2008, 2009, and 2010 were compared to predictions to validate the model. Modeled mortality from November to March, April, and May resulted in survival rates of, respectively, 22, 5, and 1.2%. Starvation from November through May thus may explain the two orders of magnitude variation observed for herring recruitment in Prince William Sound if there was no starvation for cohorts leading to peak recruitment levels (~ 1 billion age-3 herring). November and March energy observations of cohorts recruiting at 1 billion are needed to resolve whether low energy conditions at the beginning of winter or starvation during winter might drive recruitment. Low energy levels in November may be due to lack of sufficient high-energy forage as well from energy losses such as those caused by external parasites. For example, recent in-situ observations of multiple sea-lice, actually parasitic copepods, on age-0 herring during their first months following metamorphosis suggest this as an energy sink.

Gulf of Alaska rockfish "patch" characteristics

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Research trawl surveys in Alaskan waters have demonstrated that rockfish are often patchily distributed, but the pattern of spatial aggregations (or "patches") have not been quantitatively examined. In this study, we used acoustic methods to describe near-bottom rockfish aggregations observed in Gulf of Alaska bottom trawl surveys in 2007 and 2009, and in a rockfish research survey in 2009. We applied a school-detection algorithm to acoustic data recorded during the daytime at trawl locations which had a high proportion of rockfish. Fish schools near the sea floor were described and compared using a variety of response variables that measure aggregation size, morphology, and backscatter strength and variation. Acoustic patterns were divided into two categories: 1) "layers" of continuous backscatter greater than -75 decibels (dB) that extended > 800 m (approximately the length of the trawl path in the 2009 rockfish survey); and 2) "discrete" aggregations of backscatter < 800 m. One hundred and twelve rockfish aggregations were detected (89% discrete). A wide range of rockfish aggregation's shapes and morphologies were observed. For example, the length of the discrete aggregations ranged from 17 m to 445 m, with a coefficient of variation of 0.94. The variation in backscatter intensity within the discrete aggregations was larger than that observed in the layered aggregations. The wide variation of observed rockfish aggregations reveals the difficulty of using a single morphological descriptor to describe rockfish aggregations.

Predicting Distributions for Estuarine-associated Fish in Southeast Alaska

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For many commercially harvested species in Alaska there is a lack of basic information on species distribution and habitat use, especially for early life stages. Surveys conducted by the National Marine Fisheries Service between 1998 and 2006 have documented that more than a third of the federally managed commercial fish species occur in Southeast Alaska estuaries, many of them as juveniles; however very little is known about the species-habitat relationships for these estuarine systems. This study modeled the spatial distribution of fish species in Southeast Alaska estuaries in relation to environmental factors and assessed the ability of the models to predict fish occurrence in areas where environmental data are available but biological sampling has not occurred. Results from this research are expected to increase understanding of the environmental mechanisms affecting the spatial distribution of species and assist in identifying essential fish habitat and prioritizing management measures for these species.

A Test of the Optimal Stability Hypothesis in the Gulf of Alaska and the waters off British Columbia

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Regional coastal conditions have a strong influence on juvenile salmon survival during their critical first months in the marine environment. By restricting turbulence, an increase in stability allows more phytoplankton to remain in the euphotic zone, but it also leads to a decrease in the resupply of nutrients to the surface. A weakly stratified water column allows a resupply of nutrients to surface waters, but may move phytoplankton over larger vertical distances and out of the euphotic zone. In northern regions, such as the Gulf of Alaska, macronutrients are not limited but primary production is limited through low light levels during part of the year. In low latitude areas, such as the waters off British Columbia, light levels are higher and more uniform throughout the year, while macronutrients are limited in the surface layer. Therefore, at high latitudes salmon survival is likely to be favored if water column stabilities increase, whereas stability may have the opposite effect at lower latitudes. We explore the relationships between regional water column stabilities and pink salmon survival rates for hatchery stocks ranging from British Columbia to Kodiak Island.

Growth and changes in body composition over winter in YOY Pacific herring (*Clupea pallasii*) from PWS

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Overwinter survival during the first year of life can be vital in determining year-class strength of high latitude fish stocks. Survival of young-of-the-year (YOY) fish often depends on having energy stores sufficient to ensure survival until food abundance increases in spring. We are assessing the potential use of growth rates and body composition as indicators of overwinter performance for YOY herring in Prince William Sound (PWS). Our working hypothesis is that fall growth predicts winter survival. In this first year of our three-year study, we found that overwinter changes in size, growth (indicated by RNA/DNA ratio) and body composition of herring differed among five bays in PWS. Among fall samples, YOY in Simpson Bay had the lowest size, lipid and low RNA/DNA. Scarcity of YOY there the following spring suggests high overwinter mortality. In contrast, YOY herring from Eaglek and Lower Herring Bays survived winter, but experienced size-dependent mortality. This was indicated by increased average lengths and decreased dry mass and lipid. Consistent with our hypothesis, fall herring from Eaglek and Simpson bays had lower RNA/DNA and appeared to experience greater reductions in YOY abundance than Lower Herring Bay. Sample sizes in Zaikof and Whale Bays were too small to evaluate. These data demonstrate that fall condition and the quality of over wintering habitat are likely to affect recruitment of YOY herring. Future integration with abundance data from collaborators in the PWS Herring Survey should further clarify the relationship between fall growth and condition measures and spring abundance.

Autonomous underwater animal tracker

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Scientific Fishery Systems, Inc. (SciFish) and its teammate ANT, LLC have developed an autonomous underwater animal tracker, an underwater robot that can follow a crab or fish for weeks to months at a time. Satellite tracking has allowed huge, rapid advances in understanding behaviors and requirements of large animals. The opportunity to extend tracking to a wider range of marine life using an autonomous underwater animal tracker is expected to yield similar advances. To produce this robot, we have modified an underwater glider so that it is capable of detecting, localizing and tracking an acoustic transmitter attached to a drone. Future developments will lead toward the capability to track a marine animal that has an acoustic transmitter attached to, or embedded in, its body. We will describe the basic design of developed system. We will present results from field tests conducted with the system in Skilak Lake, Alaska, which demonstrated consistent and correct functioning of the underwater tracker. We will also discuss the lessons we have learned and how they redirected our ongoing development effort.

Changes in Body Composition of *Clupea pallasii* Over Winter

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Prey scarcity causes juvenile herring (*Clupea pallasii*) to lose energy over winter. As energy is lost, chance of survival is believed to decline, impacting the strength of recruitment. Energy loss occurs during both fasting and starvation. Fasting fish are able to maintain energy reserves, and upon re-feeding, are able to quickly regain energy. Starvation, however, depletes energy reserves, and cardiac and intestinal tissues are catabolized to meet daily metabolic requirements, making recovery more difficult for starving fish than for fasting fish. To determine whether fish were fasting or starving over winter, we studied 34 herring from Prince William Sound, Alaska, sampled before and after winter. We conducted calorific, proximate and lipid class analyses to identify the contribution of storage and structural elements to total energy loss. Additionally, we compared the heart mass allometries from the same fish. We concluded that the herring were starving over winter as they demonstrated all the characteristics of starvation. Herring lost 36% of their total energy over winter. The predominant storage lipid triacylglycerol decreased by 68%, accounting for less than 25% of the energy lost. Structural elements such as phospholipids and proteins accounted for more than 50% of the energy lost, and declined by 66% and 16% respectively, indicating catabolism of cells. Furthermore, the changes in the allometry between heart mass and length indicated that starvation affected small fish more severely than large fish. In conclusion, we found that energy loss was due to starvation, and that this starvation was most severe for small fish.

Predator-prey associations in a nearshore ecosystem, W. Cook Inlet: Implications for a high degree of coupling over small geographic areas

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Baseline surveys have been conducted from 2004 to 2010 to assess local fish and invertebrate assemblages prior to potential nearshore development on the west side of Cook Inlet. Samples were taken over a broad geographic range to quantitatively examine both occurrence and the degree of utilization of several benthic habitats. Several methods were employed to sample fish and potential demersal prey items (bottom trawl and beach seine) and potential infaunal prey species (VanVeen grab and cores). The various sampling methods were localized around potential development sites. In addition to characterizing local assemblages, we conducted stomach content analyses (SCA) as a measure of utilization of prey resources by a subset of ecologically and/or economically important fish species. The intention was to determine important food resources in the various locations and compare those findings to available prey species (epibenthic and infaunal). The results suggest a strong trophic link between shallow soft bottom infaunal assemblages and the associated fish assemblages. Some fish species display a highly opportunistic feeding strategy, consuming whatever is available; while others are specialist feeders, relying almost entirely on a sole food source. There is an apparent strong agreement between the dominant functional groups present in the infauna assemblage within a particular site, and what is consumed by local fish. This suggests strong coupling between the soft bottom benthic habitats and the fish that utilize them, most likely through opportunistic foraging. This also suggests small geographic foraging areas, especially for fish species such as starry flounder and yellowfin sole. Overall, these results suggest a strong, but not unexpected, linkage between the benthic infauna and higher trophic levels.

Mercury Levels in Marine Fish: A Subsistence Food Source for Alaska Natives

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Alaska Natives rely heavily on subsistence hunting and fishing for their nutritional needs, particularly in remote areas of the state. The appearance of a bioaccumlative toxin such as mercury in subsistence foods like marine fish can represent a major health threat. This study, as well as two past projects that it builds upon, provides baseline data that is integral to identifying linkages between mercury in our environment and their potential impact on Alaska Native health. This project examined marine fish data from 19 species of fish. The data was examined spatially using ArcGIS to look for associations between species, geographic locations, and total mercury concentrations. Marine fish with the highest levels of total mercury are found along the east part of the Kenai Peninsula, into Prince William Sound and down along Southeast in species that are top predators or long-lived. Seven of the fish species had samples that were over the Environmental Protection Agency's action level of 0.50 ppm for total mercury: Lingcod, Rougheye Rockfish, Sablefish, Salmon Shark, Yellow Irish Lord, Yelloweye Rockfish, and Spiny Dogfish. Five of the species had samples that were over the Food and Drug Administration's level of concern of 1.00 ppm for total mercury concentration: Lingcod, Sablefish, Salmon Shark, Yelloweye Rockfish, and Spiny Dogfish. More information is needed about mercury accumulation in marine ecosystems, and mercury levels in Alaska Natives that eat these fish before any conclusions can be made about the connections between subsistence harvested marine fish and the health of Alaska Natives.

An Atlas of Alcid Blood Cells

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The complete blood count (CBC) is an essential tool for surveying the health of an animal. A blood sample is collected and analyzed to measure components such as red blood cell volume and platelet numbers. An important portion of the CBC is measuring the white blood cell (WBC) count. If WBCs are elevated, infection may be present in the animal. Most mammalian blood can be processed through an automated CBC machine, however, that is not true for birds. Unlike mammals, avian red blood cells and platelets are nucleated causing erroneous results for all parameters when processed through such machines. Therefore, for birds, an indirect method to measure WBCs is often utilized. Part of the protocol involves completing a differential of a blood smear to quantify the various white blood cells. Identifying all the cells in a smear properly is essential when calculating an accurate white blood cell count. This poster illustrates red blood cells, thrombocytes, heterophils, lymphocytes, monocytes, eosinophils, and basophils of five different alcid species. Examples are shown for the pigeon guillemot (*Cepphus columba*), rhinoceros auklet (*Cerorhinca monocerata*), tufted puffin (*Fratercula cirrhata*), horned puffin (*Fratercula cornicualta*) and the common murre (Uria aalge). Certain cells can look similar across avian species, but there are subtle differences that need to be recognized when performing a differential.

When Do Alcids Molt? Data From Captive Alcids

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Little is known about the molt cycles of alcids due to the remote locations they inhabit. After the breeding season, the birds leave their coastal rookeries and travel to open water to molt, making locating and monitoring them difficult. The Alaska SeaLife Center houses five species of alcids (Horned Puffins, Tufted Puffins, Rhinoceros Auklets, Common Murres and Pigeon Guillemots), in an open air aviary with natural lighting. The salt water diving pool is 21.5 feet deep. Sea water is pumped in from Resurrection Bay and ranges from 42 to 48˚F. The birds are exposed to similar weather conditions, and have shown similar cycles to wild alcids, for example comparable breeding cycles have been observed in wild alcids in the Resurrection Bay area. Daily observations were conducted as well as dates of total primary feather loss. Opportunistic measurements were taken of the 9th primary feather as they grew in. Two classes of nonlinear growth curves were fit to data points based on scatter plots of initial samples. It was noted that the primary feather molt varied depending on the species, age and breeding status, most of the molting happened during September and March. In the future, further molt data and feather growth measurements will be recorded to compare annual and individual molt patterns.

Low Pathogen Avian Influenza in a Yellow Billed Loon (*Gavia adamsii*)

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On 20 April 2010, birders encountered an emaciated Yellow Billed Loon (*Gavia adamsii*) unable to fly outside of Juneau. The bird was easily captured and transferred to the Alaska SeaLife Center for rehabilitation. Multiple superficial lesions on the legs, feet, and mouth were noted. Histopathological examination of representative biopsies indicated inflammation with intralesional bacteria but no viral inclusions and was interpreted to be consistent with healing following superficial trauma. As part of routine screening, serum was tested and found positive for antibodies to avian influenza using the AGID assay that does not differentiate between high and low pathogenicity. The loon was euthanized on 27 May 2010 and additional samples were submitted for testing. A combined choanal/cloacal swab obtained and frozen at admit and repeat swabs obtained postmortem were submitted to the USGS National Wildlife Health Center for RT-PCR testing. Testing of the admit sample suggested the loon might have been shedding low pathogen virus consistent with the wild type virus found in wild birds but the test was reported as negative. The post mortem sample detected no viral RNA at all and was also reported as negative. Necropsy findings included disseminated parasitism with secondary vasculitis and tenosynovitis but did not include changes consistent with a concurrent influenza infection nor did the loon exhibit clinical signs consistent with avian influenza. Few loons have been tested for avian influenza and, to our knowledge; this is the first one that has tested positive.

Statewide Avian Rescue and Response by the Alaska SeaLife Center Stranding Program

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Since 1997, the Alaska SeaLife Center (ASLC) has admitted over 700 birds representing 90 species of aquatic and terrestrial species. Species have included Bald Eagles (*Haliaeetus leucocephalus*), Stellers (*Polysticta stelleri*), Common (*Somateria mollissima*), Spectacled (*Somateria fischeri*) and King (*Somateria spectabili*) Eiders. Birds have been rescued from all regions of the state including Barrow, Diomede Island, Ketchikan, and the Aleutian Islands. The Alaska SeaLife Center works closely with other avian rehabilitations facilities in the state to care, place and release birds back to their original location or in the migratory pattern they are currently in. ASLC works under a permit from USFWS and has responded to two mass stranding events involving Common Murres (*Uria aalge*) in South-Central Alaska. More common reasons for stranding include malnutrition, trauma and human interaction. Although bird rehabilitation can be a challenging and unsuccessful endeavor, over 200 birds have been released or transferred for continued care or a permanent facility. Each bird that is admitted into the ASLC is thoroughly examined and samples are collected from both live and dead patients to help monitor for avian diseases and maintain a database of samples for future analysis.

Developing Cell Culture Methods and Bioassays for Harlequin Duck (*Histrionicus histrionicus*) Research

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Cell culture methods can provide high-throughput testing with multiple repeats, enabling species-specific testing under controlled laboratory conditions. Cell culture techniques have been used for a variety of purposes, such as investigations into possible injury or damage from toxic substances at the cellular level. We have established hepatocyte cell culture methods and bioassays for the harlequin duck (*Histrionicus histrionicus*), a species which has not recovered from the 1989 Exxon Valdez oil spill, to assess cellular level pathology and biochemistry in this species. Using harlequin duck and surrogate mallard (*Anas platyrhynchos*) cell lines, we began with methods for hepatocyte cell extraction and culture. Hepatocyte cells were then monitored for growth characteristics, health, and morphology using microscopy to validate extraction techniques and optimum time frames for bioassay testing. A panel of cellular bioassays is also being developed and validated to examine cellular, enzymatic, and genetic damage from hydrocarbon exposure. We have tested assay reagents (e.g. dimethyl sulfoxide) for non-specific toxicity and used positive control reagents (e.g., chrysene) to establish baseline responses for each cell line. The use of harlequin duck cell lines for bioassays offers a novel technique to examine species-specific toxicological responses.

Passive Acoustic Monitoring and Visual Observation Comparison for the Detection of Cook Inlet Belugas (CIB) in Eagle Bay

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Passive acoustic monitoring is a technology that is increasing in its use to detect the presence of species that are not readily visible in the marine environment. Ecological Acoustic Recorders (EARs) are digital, low power systems that record ambient sounds up to 30KHz to an onboard 120 Gb disk on a programmable schedule. Deployed at varying depths, the EARs are recovered by activating an acoustic release that allows the unit to float back to the surface. POrpoise Detectors (PODs) also record and store acoustic information that is the result of sounds passing through filters and a microprocessor to detect echolocation clicks. Echolocation click rate is commonly used as an indirect measure of the behavior of small odontocetes. We deployed 3 EARs, in the dynamic cold water, high current, high tidal exchange environment of upper Cook Inlet Alaska and compared the acoustic detections of CIB over 108 days in 2009 to visual observation collected from shore during 80 overlapping days. Both visual and acoustic detections were very low until mid-August, when CIB seemed to move into the area. An average of 11.5 whales were visually present once the whales arrived, with a maximum of 71 CIB observed in a single day. Acoustically CIB were most active from midnight to 6am. The acoustic and visual methodologies independently confirmed the arrival of the CIB in mid August. Multiple methods for detecting CIB in Eagle Bay appears to be optimal.

Vibrissae growth rates: a tool for determining the timing of ecologically important events

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Steller sea lion vibrissae grow continuously and are not shed so they represent a carbon and nitrogen record that can be used to assess foraging strategies, movements between habitats, and the occurrence of weaning. Knowledge of the vibrissae growth rate is important in understanding the timing of these events. In past studies, growth rate was assessed from adult captive animals and from the annual isotope cycles present in the vibrissae of harvested animals. In this study, we used vibrissae that were collected from wild animals of known-age and from wild animals that were used in the Alaska Sea Life Center's Transient Juvenile Program. In both cases, vibrissae were collected from known individuals at two time periods separated by months. The longest whisker was removed at each collection and analyzed for δ13C and δ15N. Vibrissae growth between the two collection times was determined by measuring the distance from the root to a common isotope focal point. The average growth rate for the wild recaptured animals was 0.86 (± 0.28) cm/month and the average growth rate for the transient juveniles from the Alaska Sea Life Center was 0.72 (± 0.29). The growth rates measured in this study were 2-4 times greater than what has been reported in past studies. The influence of factors such as sea lion mass, length, girth, total body fat, lean mass, age at capture and month of capture will be discussed.

Development of a catalog of left-side digital images of individually-identified Cook Inlet Beluga Whales (*Delphinapterus leucas*)

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Photo-identification has proven to be a useful method for studying Cook Inlet beluga whales (CIBW), listed as ESA endangered in late 2008. The CIBW photo-id study has been ongoing since 2005, and has demonstrated that a large number of beluga whales in Upper Cook Inlet possess distinct natural marks that persist across years, and that these marks can be effectively identified and re-sighted with digital photography. A catalog of digital images of the right sides of individually-identified beluga whales photographed over six field seasons has provided information about the distribution and movement patterns of individually identified beluga whales and the Cook Inlet population in general, including residency/movement patterns, habitat utilization patterns, reproduction, injury, disease, mortality, and abundance. The catalog was recently expanded to include archived (but previously uncataloged) images of left-sides of CIBW photographed between 2005 and 2008. The current left side catalog consists of 186 individually-identified belugas. A total of 110 belugas were first identified in 2005; 42 new individuals were added in 2006, 22 in 2007, and 12 in 2008. Fourteen whales were observed in each of the four years (2005-2008). Resighting histories (i.e., dates and locations of sightings) were compiled for all belugas identified from left-side images; here we present resighting histories of mother-calf pairs, belugas with distinct marks from NMFS satellite-tagging (conducted between 1999 and 2001), and whales observed every year between 2005 and 2008. Efforts are underway to link both sides of the catalog and consolidate all photo-id data into a single comprehensive database.

Patterns of attendance of harbor seals in tidewater glacier inlets

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Large numbers of harbor seals (*Phoca vitulina*) use some tidewater glaciers in Alaska for pupping, breeding, and molting. Glacial fjords are popular tourist destinations; however, visitation by numerous vessels can result in disturbance of seals during critical life-history phases. We explored patterns of harbor seal attendance at a site frequented by cruise ships and day-trip vessels originating from Alaska's capital city. Our objective was to document diurnal and seasonal patterns of attendance to determine optimal times for vessel visitation to minimize disturbance to harbor seals. In 2008-10, we radio-tagged 107 seals (53 females, 54 males) in Endicott Arm, Southeast Alaska, and remotely monitored presence/absence of tagged seals in this and an adjoining glacial inlet (Tracy Arm). We had numerous locations for 97 tagged seals (n=63 were ≤1.75years, n=34 were >1.75yrs). There was no difference between sex or age classes in number of days located (mean 34.7 ± 1.98SE), or total number of locations per day (mean 1,347 ±81). There was no difference between sexes in elapsed calendar days of locations (mean 65 ±2.7). Older animals had more elapsed days and were detected later in the season, likely due to molting later than younger seals. On average, seals were more likely to be hauled out around noon (median ~13:00); the strength of the midday peak varied among years but seals were more likely hauled out between 09:00-17:00 (interquartile range 07:00-18:00). At a minimum, the best time for vessels to visit to minimize disturbance to seals would be before 10:00 or after 15:00.

Land-Based Beluga Observations from Northwest Fire Island, Upper Cook Inlet, Alaska, June-November 2009, and May-Nov 2010

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Information on beluga whale presence, habitat use, and behavior in the Ocean Renewable Power Company's (ORPC) proposed Cook Inlet Tidal Energy Project Deployment Area near Fire Island, Alaska is critical for evaluating potential project effects and for meeting regulatory requirements. Several beluga surveys had been conducted in Cook Inlet; however, there was little information specific to Fire Island.

The primary objective of this study was to assess the distribution and movement of beluga whales in and around ORPC's Deployment Area near Fire Island. The study was adapted from projects at the Port of Anchorage, Knik Arm Bridge, and Seward Highway. Observations were conducted during ice-free months of 2009 and 2010. Observers recorded number, location, direction of travel, behavior, and relative age class of whales. Whale locations were recorded using a theodolite.

Visual observations were conducted for 73 days in 2009 and 45 days in 2010. Belugas were seen on 42% and 38% of the observation days in 2009 and 2010, respectively. In both years, belugas were most-often seen in and around the mouth of the Little Susitna River. Belugas were not seen in or near (<1.5 km) the proposed Deployment Area in 2009; but were seen in this area on 5 days (11%) in 2010. The low frequency of belugas near northern Fire Island is consistent with other studies that have demonstrated patterns of belugas congregating elsewhere in the rivers and bays of Upper Cook Inlet during the summer and fall.

Blood parameters on live-captured harbor seals in Endicott Arm, Alaska

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Recent data suggests that the population of harbor seals (*Phoca vitulina*) in Tracy and Endicott Arms of Southeast Alaska are in decline. Animal health is one factor that could have a bearing on population status. In order to assess health, we examined several blood parameters. Specifically, data on white blood cell count, hematocrit, and total protein were collected and compared between sexes and across four age groups (pups, yearlings, sub adults, and adults.) Approximately 66 harbor seals were live-captured in Endicott Arm, Alaska between 29 April 2010 and 6 May 2010. Blood was centrifuged to determine hematocrit and total protein was determined from the serum. Average hematocrits ranged between 59.5 and 60.7 in females and 58.8 and 60.4 for males. Average white blood cell counts ranged between 12,125 and 13,131 in females and 12,894 and 15,120 in males. Eventually, this year's blood parameters will be compared to previous years.

Humpback Whale Predation at Salmon Enhancement Facilities

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In recent years, salmon enhancement facilities (SEFs) have reported humpback whales feeding upon newly released salmon fry and smolts, threatening the success of these programs. In spring of 2010, five organizations collaborated to 1) evaluate the relationship between salmon releases and humpback whale presence, 2) describe whale feeding behaviors near SEFs and 3) identify environmental conditions or cues that affect humpback whale presence at SEFs. Staff observed five release sites located in Chatham Strait along the eastern shoreline of Baranof Island between April 28th and June 24th 2010. Whales were reported at all release sites in groups of one or two, however the likelihood of sighting a whale during an observation period differed significantly (F-ratio=5.6554, df=4, p=0.0002) among SEFs ranging from 3% to 21% of observations periods. Whales were more likely to be seen on the day following a release than after non-release days and the relationship was significant ($\chi 2$=14, df=1, p=0.0002). There was a significant relationship between skiff activity near the release site and whale presence ($\chi 2$=5.948, df=1, p-value=0.0147). Whales used net pens, docks, the shoreline and bubbles as barriers to assist in prey capture. By photographing the distinctive ventral surface of the flukes, we identified individual whales observed feeding directly on releases. One whale was observed feeding at the same SEF during releases in 2008. The results of this pilot study will help direct future studies to find an effective method to protect salmon releases and mitigate humpback whale foraging on this unnatural prey source.

Evaluation of diet composition of free-ranging pinnipeds

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The harbor seal (*Phoca vitulina*) population of Tugidak Island, Alaska, declined significantly starting in the late 1970s and, since the early 1990s, has begun to slowly recover. The 'nutritional stress hypothesis' proposes that a change in the components of the diets of pinnipeds results in an alteration of the availability or quality of prey items and may be a contributing factor to the decline or slow recovery of a population. Prey hard-part remains from harbor seal scats are being isolated, identified to the lowest possible taxon, and approximate prey composition of the diet hard parts is determined from the frequency of occurrence. The MIXIT-WIN computer software program is being used to determine the nutritional profile of the estimated diets using a prey nutritional database developed from analyses of various prey found in Alaskan waters. By estimating dietary prey proportions along with estimates of pinniped needs, the nutritional value of the diet can be predicted. Differential prey composition of diets between the seal sexes is also being analyzed to evaluate the sex-specific importance of different prey. Changes in average diet composition and nutritional quality over time will also be examined. By applying the MIXIT-WIN program for use in free-ranging pinnipeds, researchers will have a tool that enables the analysis of nutritional data in a common format; facilitating our ability to compare data from different studies and to observe how the nutrition of free-ranging pinnipeds changes over time, which may provide insights regarding evaluating the potential causes for changes in pinniped populations.

Presence-only evaluation of right whale habitat suitability predictions using zooplankton data

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We evaluated predictions of right whale habitat suitability developed from historic whaling records using contemporary zooplankton data. We constructed an evaluation data set by compiling the copepod data from a number of zooplankton surveys including 3 directed multi-year surveys in 1) the Southeast Bering Sea shelf, 2) the eastern and 3) northern Gulf of Alaska. To reduce the effect of a sampling bias among the different surveys, we classified the data (abundance, wet or dry biomass) into 5 classes based on percentiles after normalizing the distributions, giving 5 levels of relative copepod abundance. We evaluated the habitat predictions at two spatial, two temporal, and two population scales. To measure model performance we calculated the Boyce index (BI - Hirzel et al. 2006) using both the full evaluation data set and a spatially restricted subset (to 60%) to test a reduced set of presence values. Our initial results suggested the summer NE subpopulation model performed notably better than the annual model, however the spring model performed poorly, with higher zooplankton densities observed at low predicted suitability. The BI was sensitive to spatial extents of the study area, and to assumptions about the evaluation data set. We therefore compared the BI to a related statistic (skewness) and explored how the two responded to changes in extent and prevalence. We also examined their sensitivity to (largely implicit) assumptions about the evaluation data. An understanding of these influences will advance our ability to truly evaluate predictive models of species habitat.

How “resident” are resident-type killer whales in Alaska?

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Mammal-eating “transient” and piscivorus “resident” eco-types of killer whales have been well studied using photo-identification methodology throughout southeastern Alaska (SEAK) and Prince William Sound (PWS). However, inclement weather and short days during both fall and winter have restricted studies to summer and protected near-shore waters. Resident-type killer whale pods, designated AF and AG, have only been observed in SEAK and PWS. The extent to which they range throughout the Gulf of Alaska is unknown, particularly in seasons other than summer. Here we report on 37 days of movements of killer whale AF42, tagged with a satellite-linked transmitter on 22 September 2010 within the inland waters of northern SEAK. After remaining in SEAK for 10 days, AF42 (and presumably other AF pod members) moved northwest following the shelf break towards PWS. Passing PWS, AF42 continued southwest along the coast of the Alaska Peninsula to the area off Chignik, an extension of the known AF pod range. After a few days near the islands off Chignik, AF 42 moved northeast to Kodiak Island, remaining in the near-shore waters around Kodiak until the last transmission. These results suggest that resident-type killer whales in Alaska may range more widely than previously thought, at least in the fall. Additional tag deployments will be needed to adequately assess the seasonal movements of this eco-type, thus providing valuable insights into habitat use. These data will be important in understanding the role that resident killer whales play in the Gulf of Alaska eco-system.

Spatial Variability in the Interactions between Humpback Whales and Pacific Herring

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As humpback whale populations increase there is growing recognition that we need to reevaluate our conception of their importance in shaping marine communities. The direct and indirect effects of whales on marine ecosystems are largely unknown because they were decimated prior to our appreciation of their ecological services. For the last three years we have studied the effects of humpback whales on three Alaskan herring populations. Humpback whales directly affected herring through predation as indicated by our observation that whale consumption could account for nearly all the winter mortality of herring in Prince William Sound. Alternatively, whales had little direct effect on herring in Sitka Sound, were herring are commercially exploited. Humpback whales in Sitka Sound focused their early winter foraging on euphausiids. In some years herring were not selected until late winter. In Lynn Canal, we observed indirect impacts of humpback whales on the schooling behavior of overwintering herring. Whales appeared to inhibit the winter shoaling behavior of herring, making the herring susceptible to predation by other predators such as Steller sea lions. These data demonstrate that arguments associating increased whale abundance with declines in commercially valuable fish stocks are oversimplifications. Whales show a high degree of fidelity to their foraging grounds, so their effects are exerted over relatively small spatial scales. Moreover their effects depend on the structure of the population they forage upon and the availability of alternative prey. In addition whales may provide important services such as making prey available to other predators.

Cook Inlet beluga whales and the tidal energy project: Understanding the permitting process

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Cook Inlet is home to some of the greatest tidal energy potential in the United States, as well as an endangered population of beluga whales (*Delphinapterus leucas*). Successful permitting and operation of a tidal power project in Cook Inlet requires a rigorous biological assessment of the potential and realized effects of the physical presence and sound footprint of tidal turbines on the distribution, relative abundance, and behavior of Cook Inlet beluga whales. This assessment has involved both visual and acoustic surveys, consultations with a wide variety of federal, state, and local agencies, and scoping and informational meetings with interest groups and the public. Here, we provide a description of the processes that have been followed as the Tidal project has been developed, and summarize the types of information that have been collected to meet the permitting requirements. This is not intended to summarize the actual data, but rather to provide the public with information on the processes involved in ensuring that the development of this alternative energy source meets all regulatory and environmental requirements and will not harm the local beluga population.

Posters: Gulf of Alaska
Mammals

Annual calving rate indices for Cook Inlet beluga whales 2005-2010

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The Cook Inlet stock of beluga whales is genetically distinct and geographically isolated from beluga populations around Alaska and the Arctic. In 1999 this population was determined to be depleted under the U.S. Marine Mammal Protection Act, and in 2008 it was listed as endangered under the U.S. Endangered Species Act (ESA). Efforts are underway to develop ESA recovery criteria for this population. An early indicator of change in growth or decline of a population is change in the calving rate. To develop a calving rate index, NMML conducted aerial surveys each August beginning in 2005. These surveys seek out groups of beluga whales and circle them to estimate size of the group and the fraction of calves. Video recordings are collected during multiple passes over the whale groups. Group sizes are estimated from a wide-angle video. The fraction of calves is estimated from high resolution zoomed in video which samples a portion of the group but shows the calves clearly. Size coloration and proximity to adults are used to identify images that represent calves. While there is good agreement among readers regarding which images represent calves it is uncertain whether these are only age zero calve or also include age one calves. Ratios from each sampled group are averaged. These averages are then applied to estimated group sizes to determine a calving rate index for the population each year. The calving rate indexes are used in an age and sex structured population model to gauge population growth rates and to evaluate the extinction risk and intrinsic growth rate of this endangered beluga population.

Serological and Parasitological Survey of Harbor Seals (*Phoca vitulina*) in Glacier Bay National Park, Alaska

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The harbor seal population in Glacier Bay (GLBA) Alaska has declined by 75% since 1992. This decline may be due to a change in prey availability, disturbance from cruise ships that visit the area, biotoxins, disease, or a combination of factors. We collected and analyzed biological samples (serum, whole blood, and feces) from 99 harbor seals captured in GLBA National Park, Alaska (2007 and 2008) to determine exposure to several bacterial, viral, and parasitical disease agents (*Brucella* spp., phocine and canine morbillivirus, *Leptospira* spp., *Toxoplasma gondii*, *Cryptosporidium* and *Giardia*) *Brucella seroprevalence* ranged from 0 - 74.2% and was highly assay dependant (*B. abortus* card test: 17.2%, *B. abortus* plate test: 74.2%, cELISA: 36.6%, *B. ovis* ELISA: 0%, *B. canis* RSAT: 0%). Serum was analyzed for five serotypes of *Leptospira interrogans* (Hardjo, Icterohaemorrhagiae, Canicola, Grippotyphosa, and Pomona). Prevalence of each serotype ranged from 0-14.1% (a mean serotype prevalence of 15.2%). *Toxoplasma gondii* was negative for all animals in both years. Harbor seals were negative for antibodies against Phocine and Canine Distemper Virus. All fecal samples were negative for the protozoa *Cryptosporidium*, and only 2 of 33 (6.1% prevalence) were positive for *Giardia*. Prevalence of disease agents of harbor seals in the GLBA will be compared to previous years to assess potential changes in disease status or serve as a baseline for future monitoring.

Posters: Gulf of Alaska
Mammals

Measuring disturbance: a balance of tolerance and reluctance

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Assessments of anthropogenic effects on marine mammals often are based on tolerance measurements indicated by distances at which animals respond to perturbation sources with characteristic behaviors (e.g., leave haulout). Habituation can occur when the stimulus does not provide positive or negative reinforcement and is indicated by increased tolerance over time. Conversely, sensitisation is associated with positive or negative reinforcement and may be characterized by animals responding at increasing distances over time. Where humans and marine mammals frequently interact, it is hoped that negative and positive effects associated with interactions are sufficiently rare that marine mammals habituate and behave as if humans were not present.

In Aialik Bay, a tidewater glacial fjord in southcentral Alaska, we recorded reactions of harbor seals (*Phoca vitulina*) to our 4 m Zodiac during daily transits to Squab Island conducted from May-August, 1979-1980. Observations included date, time, age category, and distances seals entered the water. Seals (n=425) abandoned the ice at a median distance of 35m (range = 3m – >250m) from the vessel. Adults without pups and juveniles entered the water at greater distances (median =40m) than females accompanied by pups, their pups, and weaned pups (median=30m). Young pups remained on the ice longer in 1979, when ice availability was more limited, than in 1980. Delayed responses of pups caused more frequent temporary separations from mothers. Results indicate that distances seals enter the water reflect a balance between tolerance and reluctance to leave haulouts and that responses of young pups demonstrate sensitivity to cold water exposure.

All Tied Up: Taking a Closer Look at Humpback Whale Entanglement in Alaska, 1990-2009

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Entanglement is a significant source of anthropogenic injury and mortality for humpback whales in Alaska. From 1990-2009, most incidents reported to NOAA Fisheries occurred in Southeast Alaska, with the majority of reported events involving crab, shrimp, and unidentified pot gear, as well as gillnet and other unidentified net. These types of entanglements can be life threatening to humpback whales by inhibiting their ability move, breathe, and forage. Entangled animals may also experience physical trauma from gear, develop infections from wounds, and be susceptible to other threats such as ship strikes. Impacts such as compromised reproductive success, while not immediately lethal, may be harmful to the population over time. To address the issue, in 2005, NMFS Alaska Region partnered with NOAA's Hawaiian Humpback Whale National Marine Sanctuary to develop a response program for entangled large whales in Alaska. Since that time, numerous teams throughout the state have been trained in first response activities and workshops have been held with fishermen regarding measures to prevent entanglements. Currently, eight caches of disentanglement equipment are strategically distributed throughout the state, along with telemetry buoys and Argos/ GPS/ VHF radio transmitters designed to attach to trailing gear. Challenges remain in quantifying the impact of entanglement relative to a specific fishery and to the whales themselves due to often insufficient information obtained from these events. To improve the quality of reporting and the capacity to respond, enhanced efforts are necessary both to validate reports and stand by entangled animals until a trained disentanglement team can be mobilized. Future management and research efforts should focus on increasing awareness and outreach, event follow-up, report verification, gear investigation, and post-release monitoring.

Comparison of harbor seal (*Phoca vitulina*) body fat from four Alaskan regions with differing population trends

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Several hypotheses have been offered to explain current declines in harbor seal numbers in some areas of Alaska. Differences in body fat can offer support or opposition for these hypotheses. We examined body fat relative to population trends of harbor seals live-captured in four Alaskan regions; two currently in decline, Glacier Bay (GB) and Tracy/Endicott Arms (TE), compared to two currently increasing after a long period of decline, Prince William Sound (PWS) and Kodiak (Kod). Body fat was determined via isotope dilution (n=240). If the cause of the current declines is associated with factors such as diet, disease or contaminants, we hypothesized that GB and TE seals will have less body fat than PWS and Kod seals. Adjusted mean percent body fat values for adults of both sexes and sub-adult males were highest in Kod, followed by GB, TE and PWS, with Kod adults having significantly more fat (5-13% more; $p<0.05$) than the adults in the other regions. Adult females had significantly less fat in PWS than in GB (6% less; $p<0.05$). Subadult males and yearlings of both sexes had significantly less fat in PWS than in TE (4-6% less; $p<0.05$). The finding that seals from PWS were not fatter than seals from GB and TE does not support our hypotheses. This suggests that current declines in GB and TE may be unrelated to factors such as diet, disease or contaminants, and instead suggests removal of healthy individuals from the declining populations through factors such as emigration or predation.

Behavior and distribution of the Cook Inlet beluga whale (*Delphinapterus leucas*) pre- and during pile driving activity at the Port of Anchorage Marine Terminal Redevelopment Project, 2005-2009

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Five stocks of beluga whales (*Delphinapterus leucas*) are found in US waters. The Cook Inlet population is genetically distinct, geographically isolated from the other stocks and was recently listed as endangered under the US Endangered Species Act. Many factors are identified as potential threats to the Cook Inlet beluga whale population including coastal zone development and anthropogenic noise. The Port of Anchorage Marine Terminal Redevelopment (MTR) Project involves several types of construction activities including dredging, gravel fill, and pile driving. Pile driving is a major concern because of the potential harassment due to high source levels. We investigated beluga whale behavior and distribution pre- (2005-2007) and during pile driving activity (2008-2009) at the MTR Project. Land-based visual observations were conducted to document beluga behavior and distribution in the presence and absence of pile driving activities. Mean sighting duration of beluga whales, behavior, mean group size, group composition and group formation were compared between pre- and during pile driving activity using chi-square goodness-of-fit tests and paired samples t-tests. There were significant differences in mean sighting duration, behavior, group composition and group formation between pre- and during pile driving periods. Beluga whales were most frequently observed along the eastern shoreline of the study area; however, sightings increased along the western shoreline near Port MacKenzie during pile driving activity. A Pearson's correlation coefficient (2-tailed) was used to examine the relationship between monthly sighting and pile driving rates and there was no significant correlation between the two.

Effects of construction noise on the Cook Inlet beluga whale (*Delphinapterus leucas*) vocal behavior

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Cook Inlet beluga whales (*Delphinapterus leucas*) are genetically distinct from the other US beluga stocks and were recently listed as endangered under the US Endangered Species Act. Many factors are identified as potential threats to the Cook Inlet beluga whale population, including anthropogenic noise. The Port of Anchorage (POA) Marine Terminal Redevelopment (MTR) Project, taking place in Knik Arm, Cook Inlet, involves multiple construction activities including dredging, gravel fill and pile driving. The impacts of construction activity on beluga whale vocalizations were investigated using passive acoustic monitoring. Specifically, we tested for a difference in the detected hourly click rate of beluga whale echolocations during periods with and without construction activity. Four moored lines were deployed near the MTR Project at the beginning of the survey and multiple sonobuoys were deployed in the array during 20 d of monitoring in August and September 2009. Data were recorded in real-time at a shore-based observation station. No whistles were recorded during monitoring. An energy summation method was used to automatically detect echolocation clicks. Times with and without construction noise (dredging and pile driving) were determined from visual inspection of long-term spectral averages. The detected click rate was higher without (428.61 detected clicks/h) construction activity than with construction (291.12 detected clicks/h); however, the difference was not significant ($t(24)= -0.56$, $p=0.58$). The results indicate potential acoustic masking, a reduction in beluga whale vocalizations, or possible avoidance of the area by beluga whales during construction activity.

Body condition and endocrine profiles of Steller sea lion (*Eumetopias jubatus*) pups during the early postnatal period

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Steller sea lions (*Eumetopias jubatus*) (SSL) are the largest otariids, with the western distinct population segment currently listed as endangered under the Endangered Species Act. The aim of the present study was to quantify circulating levels of cortisol, aldosterone, total and free thyroxine, total triiodothyronine, and leptin in 61 wild pups ranging in age from 5 to 38 days old. Given that postnatal development is a period of high-energy demand and that SSL pups have a fast growth rate for an otariid, we expect body condition to be an important factor in the health of individual pups. However, no relationship between body condition index (BCI) and circulating concentration of hormones quantified in the present study was detected. The SSL pups sampled in the present study appeared to uniformly be in good body condition, which likely explains why circulating hormone concentrations assessed were not associated with the BCI. Male pups were larger than female pups in body mass, standard length and axillary girth while only cortisol and aldosterone concentrations showed differences between male and female pups with females having higher cortisol and lower aldosterone concentrations. Circulating concentrations of cortisol, total and free thyroxine, and total triiodothyronine were affected by the capture and handling inherently required in sampling wild pinnipeds. However, the overall variation attributed to the rookery disturbance was low ($r^2<0.293$). These findings are relevant for comparative endocrinology and offers baseline concentrations of several hormones for free ranging SSL pups from an apparently healthy population.

Acoustic presence of killer whales (*Orcinus orca*) in Resurrection Bay, Alaska during May-June 2010

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Killer whales produce three different types of vocalizations: whistles, pulsed calls and clicks. Pulsed calls have been studied in detail to determine their relation to social organization and behavior as well as pod or individual identification. The function of whistles is not well known, but they are thought to be used for close-range communication. Clicks are mainly used for echolocating. The vocal repertoire of killer whales recorded in Resurrection Bay, Alaska during May and June 2010 was investigated to determine their call characteristics and diel calling patterns. Data were recorded using an Ecological Acoustic Recorder, which sampled at 20 kHz on a 75% duty cycle. The characteristics of the twelve most common calls were compared to calls of known resident and transient pods (Yurk et al. 2002, Saulitis et al. 2005, respectively) to determine which pods were present in Resurrection Bay during this time. The most commonly identified calls were pulsed calls that could be used for group cohesion and to share information. Four calls could have belonged to resident pods (AD, AE or AK) and one could have belonged to the AT1 transient pod. Calling occurred more often during the day than in twilight, but there was no real night time during the survey. Daytime calling may have been used for socializing.

Acoustic and foraging behavior of tagged sperm whales (*Physeter macrocephalus*) under natural and depredation foraging conditions in the Gulf of Alaska

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Sperm whales have been depredating black cod (*Anoplopoma fimbria*) from demersal longlines in the Gulf of Alaska for decades, but the behavior has recently spread in intensity and geographic coverage. Over a three-year period 11 bioacoustic tags were attached to adult sperm whales off Southeast Alaska under both natural and depredation foraging conditions. Measurements of the animals' dive profiles, acoustic behavior, and angular velocity under both behavioral modes were distilled and examined for statistically significant differences.

The whales' natural foraging behavior is consistent with previous observations worldwide, but two rough categories of depredation were identified. The dive profiles and angular velocities of "deep depredating" whales are similar to natural dives, but their acoustic behavior is significantly different. By contrast, "shallow depredating" whales conducted dives that were shorter, shallower, and more acoustically active than natural foraging dives, but retained similar angular velocities. Animal "creak" rates, which serve as a proxy for prey capture attempts, were four times greater during shallow depredation than during natural foraging. Whales generating "creak" sounds had significantly greater roll velocities when followed by a pause in clicking, suggesting that acoustics might distinguish prey capture success from mere attempts. No unique depredation strategy exists, but "spin-off" fish may have a role in teaching animals how to depredate.

Chewing the fat, prey selectivity by fish eating resident killer whales in Prince William Sound and Kenai Fjords, Alaska

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Studies of feeding habits of resident (fish eating) killer whales using field observations and sampling of prey remains (fish scales) were conducted opportunistically from 1991-2010 in Prince William Sound and Kenai Fjords. Prey appear to be primarily Chinook salmon (*Onchorhynchus tshawytscha*) in spring, although most samples were from Kenai Fjords. In summer, whales appear to transition to chum (*Onchorhynchus keta*) and then to Coho salmon (*Onchorhynchus kisutch*). Coho salmon appear the primary prey in the fall, although most samples from that time of year were from Prince William Sound. Recently, chemical analysis (carbon and nitrogen stable isotopes, essential fatty acids, environmental contaminants) of skin and blubber biopsy samples were used to augment field observations. When the relative discriminant function positions of the same variables from tissues of killer whales and their putative salmonid prey were co-plotted, the observed trend among killer whales mirrored data from scale sampling over the course of the spring, summer and fall seasons. Chemical analysis also demonstrated unique signatures from different pods, and to some extent, different matrilines, suggesting pod specific, and at times, matriline specific, feeding habits. Matrilines termporarily split off and traveled separately from their pods, particularly in early spring, perhaps in response to low prey availability. Resident killer whales appeared to choose species of salmonid prey based on oil content, size, and availability. Small, low oil content but abundant pink salmon (*Oncorhynchus gorbuscha*) were not taken. As has been demonstrated in British Columbia, a seasonal abundance of oil rich species of salmonids may be essential for winter survival.

Tracking Whales Through Time: The Use of Photo-identification to Continue to Track Cook Inlet Beluga Whales that Were Satellite-tagged a Decade Earlier

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Habitat use and life-history characteristics of Alaska's endangered Cook Inlet beluga whales (CIBWs) are among the information needed for recovering and conserving the species. Over six field seasons (2005-2010) we have developed a catalog containing photographs of individual Cook Inlet beluga whales that were identified using natural markings. With the exception of a few whales first photographed as young-of-the-year calves, the ages of most of the whales in the catalog are unknown. Seven identified belugas have marks caused by satellite tags applied by NMFS between 1999 and 2001; although the satellite tags are no longer present, we are still able to photographically track these whales 4-11 years later. Knowledge of the years in which the satellite tags were applied helps in assigning a relative age to resightings of these previously-tagged whales. Four of these whales are presumed to be mothers, based on the close proximity of calves. Two of these whales were seen in all five years of the study, two were seen in four years, one was seen in three years, and two were seen in one year. Here we present photographs and sighting histories of previously-satellite tagged belugas, including residency/movement patterns, reproductive and survival histories, and association patterns with other satellite-tagged individuals. Information gained about these individual beluga whales can provide insights into the population as whole.

Examining maternal investment in Steller sea lions (*Eumetopias jubatus*) using fatty acids from milk

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Declines in the abundance of Steller sea lions over the past 30 years resulted in numerous studies to determine causes of the decline, and current research suggests that fecundity of western stock females has decreased sufficiently to restrict the potential for recovery. Nutritional stress can greatly affect reproductive requirements, therefore it is important to understand how dietary strategy changes in times of intense energetic requirements. Although many studies have examined nutritional limitations, little information is available on milk fatty acid (FA) signatures. Milk collected from pups can be a useful tool for examining the diet of lactating females, either qualitatively, or quantitatively using quantitative fatty acid analysis (QFASA). Our objective is to determine variation in the maternal diet of adult female Steller sea lions and how that associates with parameters of maternal care and pup survival. Milk samples will be collected via gastric intubation from Steller sea lion pups on a small rookery where individual females have been identified, and their foraging behavior is observed via remotely operated video cameras. We will identify milk FA and their relation to maternal foraging strategies to establish how FA composition changes as females switch from stored pre-parturition FA to post-perinatal period dietary FA. We will also examine the change in FA composition as milk is degraded over time to understand breakdown and utilization by pups with implications on pup survival. This study will provide useful information about maternal investment in Steller sea lions, which could have management implications for Steller sea lions throughout their range.

Testing Thermal Detection of Seals on Ice

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In August 2010, we tested a thermal (infrared) imager for airborne detection of harbor seals on ice in glacial fjords. A reliable thermal method would dramatically reduce the effort and potential errors involved in detecting and counting seals on glacial or sea ice using conventional methods of digital photography or observation by eye. The goals of this pilot study were to determine the thermal resolution threshold for harbor seals on glacial ice in order to establish the most effective survey altitude, and to identify the radiated temperature range of seals and sources of thermal interference for automated image collection. The output from the thermal imager (FLIR A325) was used to control the simultaneous collection of thermal and high-resolution visual images whenever a preset thermal threshold was detected. Thermal and visual images were collected at six altitudes between 800 and 1900 feet. Thermal hotspots corresponding to seals were visually identifiable at all altitudes, though the most reliable altitude was 1000 feet. Interference in some areas seemed to be caused by fine glacial silt that apparently reflected infrared radiation or warmed the water, reducing the contrast with seals.

Cook Inlet Beluga Whale Diet Using δ15N and δ13C Stable Isotope Analysis

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Determining whether changes have occurred in the diet of endangered Cook Inlet beluga whales (*Delphinapterus leucas*) is important for understanding whether diet was a factor in the population decline or is currently a factor in its recovery. Using bone samples from the skulls of Cook Inlet beluga whales in the collection at the Museum of the North, University of Alaska, we determined the δ15N and δ13C isotope signatures for 24 belugas collected between 1965 and 2007. Although stable isotope analysis does not allow for prey to be identified to species, general changes in diet can be detected. Bone tends to average isotope values across an individual's lifetime, so that if beluga diet changes over time we can detect those changes by comparing stable isotopes in the bones of belugas that lived before, during, and after the change. For example, if belugas switched from eating mostly chinook salmon (high trophic level) to mostly shrimp (low trophic level), we would be able to detect the change in δ15N signature of the bone from belugas collected before and after the switch. Our results show there has been a decrease in the trophic level at which Cook Inlet beluga whales were feeding from 1965 to ~1985 compared to after 1985, indicating a change in diet. Further research will be necessary to determine what species of prey were involved.

Bulls Gone Wild: Tenure and Territorial Tactics of Male Steller Sea Lion Reproductive Success

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Copulations (n=417) of Steller sea lion males (n=44) that maintained territories on the rookery at Chiswell Island, Alaska from 2001-2009 were observed using a remote video system. During breeding season (May 24th – July 15th), 14.3 ± 0.5 different males held territories at various times; yet the maximum number of males that held territories at the same time was twelve. Nearly two-thirds of males (n=33) with known tenure (years) were unsuccessful in copulating during their first year. However, there was an increase in the number of copulations observed from the acquisition year to year two, but no change was observed in all subsequent years. A cluster analysis of tenure and territorial histories for males (n=15) with observed lifetime reproductive success (total copulations) suggests five different reproductive strategies. Tactics of the two most successful strategies were: A) males copulated in their first year, retained the same territories for 3-6 years during the breeding season, and occupied territories that were centrally located where the greatest percentage of females gave birth B) males did not copulate until their fourth year and occupied different peripheral territories with fewer births over 7-8 years during half of the breeding season. Males of the remaining 3 strategies were less successful due to shorter tenure or brief durations of time spent holding a territory during the breeding season. Results indicated that greatest lifetime reproductive success was not achieved solely by time spent on the breeding area; rather, it was achieved from a combination of tenure and territorial tactics.

Using GIS to model Cook Inlet beluga whale critical habitat parameters in the Knik Arm area of Anchorage, AK

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The Cook Inlet beluga whale (*Delphinapterus leucas*) was listed as endangered in 2008. These whales are genetically distinct from other Alaskan beluga stocks due to generations of physical separation by the Alaska Peninsula. The number of whales in this population, which declined drastically in the latter half of the 20th century, has stabilized in recent years at totals well below the critical threshold estimates for species survival. These whales have shown increasing use of the edges of upper Cook Inlet, including the Knik and Turnagain Arm areas in close proximity to the City of Anchorage. Belugas' primary prey is anadromous fish including smelt (*Thaleicthys pacificus*) and salmon (*Oncorhynchus* sp.), both locally available. The presence of many anadromous streams, strong tidal fluctuations, shallow and mudflat areas, strong currents, and seasonal ice cover, appear to influence belugas' movement patterns. This area is also the site of intense shoreline development, natural resource extraction, heavy marine traffic, and municipal wastewater disposal. The proposed critical habitat for this species includes the entire in-water area of upper Cook Inlet, and is hotly contested due to the effect it would have on these industries. The purpose of this project is to use sighting data to document the close correlation between anadromous fish movements and beluga whale sightings in Knik Arm and to determine what environmental conditions are most conducive to beluga whale presence within the study area using Geographical Information Systems Spatial and Tracking Analyst programs in order to ultimately facilitate simultaneous conservation and development efforts.

Investigating the temporal and spatial distributions of marine mammal and human usages in Kenai Fjords, Alaska: A building block of Marine Spatial Planning

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The waters surrounding the Kenai Fjords National Park support a wide variety of marine life, including endangered species, and recreational activities such as wildlife tourism and sport fishing. Recently there has been a growing interest in understanding the interactions and importance of highly used areas and applying this knowledge to generate balanced and effective marine spatial planning (MSP). The objective of this study was to initiate a long-term observational database of both biotic and anthropogenic usages in Kenai Fjords that could later be applied to MSP as well as ecosystem assessments. As a first step, spatial partitioning was investigated in the summer of 2009 and 2010 using opportunistic surveys conducted aboard vessels operated by a wildlife and glacier tour company, Kenai Fjords Tours (KFT). Marine bird and mammal observations made aboard KFT vessels were used to identify seasonal and interannual variation in the distribution of marine mammals and humans primarily in Resurrection Bay, near the Chiswell Islands and in Northwestern Fjord. Data were assessed for spatial and temporal partitioning of common marine mammal species as well as human activities. Preliminary results indicate habitats of importance to specific species, productive areas that are attractive to multiple species and locations of common use by marine mammals and humans. Data from these surveys also complemented ongoing projects such as Steller sea lion brand resightings and whale photo-identification research. Repetitive spatial observations are valuable for detecting ecosystem dynamics and serve as building blocks for development of balanced management strategies.

Seals on Ice: Temporal and spatial patterns of habitat use by harbor seals associated with Northwestern Glacier, Kenai Fjords National Park, Alaska

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In Alaska, 10-15% of harbor seals use glacially calved ice as a haulout substrate to rest, molt, and care for young. In the Kenai Fjords National Park (KFNP) six tidewater glaciers terminate directly into marine fjords. Northwestern glacier, located 46 km southwest of Seward, has retreated approximately 7km in the past 40 years, which in turn has altered the habitat available for harbor seals at its terminus. The primary goal of this study was to evaluate the seasonal habitat use by harbor seals at Northwestern glacier prior to its full retreat on shore. Vessel-based surveys of seals in Northwestern fjord were conducted in the summers of 2009 and 2010 from vessels operated by a local wildlife tour company, Kenai Fjords Tours. Temporal and spatial distribution of seals, ice, and other environmental variables were evaluated across 6 sub-regions during three time periods: pupping (mid-May through June), mid-summer (July) and the molt (late July through Aug). We also contrasted data from Northwestern Fjord with seal counts conducted in Aialik Bay (20km to the northeast). These comparisons revealed complex patterns of seal habitat use suggestive of seasonal movements between fjords. Our results also suggest favorable environmental conditions within Northwestern Fjord particularly during the pupping and mid-summer seasons. Understanding habitat use and movements of seals is vital to effective management strategies. Further research is needed to identify the frequency and causes of movements between nearby glaciers by individuals, age groups, and across seasons.

Regional differences in age of weaning in Steller sea lions determined using stable isotopes of carbon and nitrogen

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Age of weaning is an important metric of population dynamics relative to prey availability. Previous estimates of weaning age were based on infrequent behavioral observation. In this study, vibrissae (whiskers) were collected with roots intact from 310 free-ranging Steller sea lions in Southeast Alaska (SEA; eastern DPS, n=112), Prince William Sound (PWS; western DPS, n=122), Gulf of Alaska (GOA; western DPS, n=17) and the Aleutian Islands (AI; western DPS, n=59) between 1998 and 2009 to determine the proportion of animals weaned in each region. Stable isotopes of carbon and nitrogen were measured in segments sectioned along the length of each vibrissae from the tip (tissue grown in utero) to the root (most recently grown tissue) to provide a timeline of changes in the trophic level of the ingested diet of the young of the year or juvenile sea lion. Sea lions were categorized as weaned if there were indications of decreased trophic level of the diet through assessment of both the carbon and nitrogen ratios near the root end of the vibrissae compared to early nursing isotopic ratios. Only 1 sea lion pup was found to be weaned in each of PWS and GOA during the first year of life. During their second year, 43.9% of sea lions sampled in SEA (18 of 41) were identified as weaned using vibrissae stable isotopes, compared to 62.5% of yearlings sampled in PWS (15 of 24) and 66.7% of yearlings sampled in AI (4 of 6).

Steller sea lion foraging behavior in Glacier Bay, Alaska

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To better understand how immature Steller sea lions use the Glacier Bay and Icy Strait region, we captured 7 yearlings and 5 young-of-year pups at South Marble Island and monitored their behavior using satellite dive recorder tags between November 2009 and January 2010. Juveniles and pups used two central-place haulouts within Glacier Bay: individuals hauled out near Tarr Inlet foraged in waters north of Willoughby Island, while those hauling out at South Marble Island foraged in Hugh Miller Inlet, Geikie Inlet and central Glacier Bay. While all pups remained within Glacier Bay, four yearlings travelled throughout northern Southeast Alaska. One individual spent the winter foraging off Cape Fairweather, two foraged off the Inian Islands within Icy Strait and one ranged as far as Tenakee Inlet and Southern Lynn Canal. While outside coast foraging trips over the continental shelf were confined to shallower depths (maximum 142 m), yearlings also exploited the deeper inside passages with dives reaching 404 m. Sea lions at Tarr Inlet and southern Lynn Canal made particularly consistent, daily, focused dives to below 300 m. Yearlings made maximum daily dive depths of 148 ± 20 m while pups utilized shallower diving ranges of 82 ± 4 m. Regardless of location, yearlings spent more time foraging during daylight than at night (30 ± 5% greater time foraging during daylight.) While pup behavior reflects that of young foragers dependent on maternal support, yearlings exhibit the more wide-ranging travel and focused diving of an independent marine predator.

Ebbs and floes of seals: Using aerial photo-mosaics to track changes in abundance of harbor seals on ice

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Harbor seals use a variety of substrates on which to haul out, rear pups and molt but their largest aggregations occur on ice emanating from tidewater glaciers in Alaska. Such ice-hauling seals present challenges for estimating abundance, particularly as their habitat comprise large areas distant from land and which are highly dynamic. Moreover, availability of ice as a platform varies according to physical processes, which are difficult to predict. Repeatable counts of these seals are thus difficult making real-time population tracking problematic. Although these haul outs may be relatively close to shore, land-based surveys are biased due to visual limitations related to distance and obscuring by rough ice. Aerial photogrammetry provides full coverage and improved, standardized detection of seals, but also requires specialized planes (with restricted schedules), cameras, and image analysis leading to high costs in time and money. We used an array of three digital SLR cameras installed in a Twin Otter, and a GIS to capture and process imagery of seal on ice. Our goal was to develop a more flexible, lower-cost method of “photo-mosaicing” to allow for complete and accurate counts annually. Counts from Le Conte Bay (range: 1979 to 1980) and Tracy Arm (927 to 938) demonstrated high accuracy with good agreement among analysts (<2 % difference). This method provides advantages over more expensive aerial mapping or land-based counts. We expect this method to promote better population monitoring and thus conservation in these important areas that are under increasing risk of impacts by rising vessel traffic.

Range contraction in a beluga whale population

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The small, isolated population of beluga whales *Delphinapterus leucas* in Cook Inlet, Alaska, USA, has had a distinct contraction in range over the past 3 decades. This contraction is a function of a decline in abundance, evidently caused, at least in part, by high takes during unregulated subsistence hunting. During the 1990s, hunting resulted in takes of over 50 whales/yr, all of which occurred in the northern portion of Cook Inlet. Concurrent with the decline in abundance, sightings became rare in the southern inlet, even though human impact had been relatively low there. Curiously, the density of whales in the northern inlet remained high in spite of the hunts. Significant changes in beluga whale distribution are evident across 3 periods: 1978–1979 (the earliest well-documented data); 1993–1997 (during the recorded decline in abundance); and 1998–2008 (when hunting was regulated and recovery was anticipated). The center of the summer range of beluga whales contracted northeastward into upper Cook Inlet from the 1970s to the 1990s (38 km; $p = 0.042$) and continued into the 2000s (total of 53 km; $p = 0.022$) with a longitudinal shift east towards Anchorage (the largest city and port in Alaska) occurring between the 1990s and 2000s (17 km; $p = 0.025$). The result is a reduced range (>7000 to <3000 sq. km) in all but the area with the highest degree of human disturbance. If and when the Cook Inlet beluga whale population begins to increase, a reoccupation of peripheral habitats may be the first indication of recovery.

Calf Proximity to Adults in Aerial Video Sampling of Cook Inlet Belugas

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An isolated, population of belugas resides year-round in Cook Inlet, Alaska. While their abundance is well documented, reproduction rates and the potential for growth are also needed to effectively manage this endangered stock. Techniques using High-Definition (HD) video recordings taken during aerial surveys have been developed to document the proportion of calves and juveniles relative to adults. In the video, small, dark gray calves and intermediate-sized, gray juveniles were easily distinguished from large, white adult belugas. Studies of beluga stocks in arctic Alaska and western Russia show newborns are always in close proximity to an adult while yearlings are often, but not always, found with adults. Given this new information, video samples of Cook Inlet beluga images were assessed qualitatively for proximity of calves to adults. Proximity codes were assigned as follows: 1) “touching adult”, 2) “within one whale length of adult”, 3) “2-3 whale lengths from adult”, 4) “in same field of view as adult”, or 5) “alone in field of view”. For code 1, the location of the calf, (leading or lagging) relative to the surfacing of the adult was also documented. While the calf proximity to adult corresponded closely to the size and color of the calf there was also a significant number of apparent calves that fell into category 5. Results from the proximity code assessments and surfacing behavior also showed significant differences in the number of probable newborns and yearlings between the June and August sampling periods.

The influence of time in captivity, feeding status, and acute trauma on blood analytes for juvenile Steller sea lion (*Eumetopias jubatus*)

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We studied the physiology of captive juvenile Steller sea lions (SSLs) at the Alaska SeaLife Center between August 2003 and September 2009. Using blood samples taken at intervals before and after procedures we wanted to determine how time in captivity, feeding status, transmitter implantation (LHX), and/or hot-branding affected measured blood analytes and the duration of any measured effects. Seventeen blood analytes were measured for 35 SSLs at 1-2wks intervals for the duration of their time in captivity (range, 6-12wks). We compared principal components (PC) scores against food intake, time since LHX, and time since hot-branding, while controlling for time in captivity using generalized linear models. We found that 4 PCs were significantly associated with one or more treatments. Dominant PC loading scores indicated that red blood cell count and hematocrit were negatively associated with food intake and were elevated 1-2wks following LHX ($p<0.01$, adj-R^2=0.48). White blood cell counts decreased with ingestion and were elevated 1-2wks following hot-branding ($p<0.01$, adj-R^2=0.49). After controlling for a positive association with food intake, globulin and total protein were elevated 1-2wks following hot-branding but remained elevated for 4wks following LHX ($p<0.01$, adj-R^2=0.58). Total bilirubin decreased with food intake and with time in captivity ($p<0.01$, adj-R^2=0.33). Knowledge of how blood analytes are affected by food intake and different forms of acute trauma could provide us with a better tool to evaluate the health and condition of Steller sea lions in the wild.

Historical time series of humpback whale abundance

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In Prince William Sound (PWS), changes in population abundance of the humpback whale (*Megaptera novaeangliae*), one of PWS's primary predator species, have until now been unknown. Using a historic dataset (1978-2009), we constructed the first time series of humpback whale abundance in western PWS. Trends in the number of whales encountered per unit effort were compared to trends in abundance estimates from mark-recapture. Photographs from this dataset were used to "mark" and re-sight individual animals using the unique pigmentation pattern on the ventral flukes of each whale. Two types of mark-recapture models were created and compared: Cormack-Jolly-Seber (CJS), which estimates probability of capture and survival, and the Pradel model, which additionally estimates a relative abundance parameter. The mark-recapture models best depicted abundance trends in this population. In both models, the population has generally been increasing over time, but the rate of this increase has been declining. The CJS model shows an increase from 52 (SE=22) to 191 (SE=32) whales (» 370%) over the time period. The Pradel model shows a slightly lesser increase of » 350%. The average annual rate of increase estimated in both models was approximately 12%, which is higher than the 5-7 % annual increase estimated for the North Pacific. With these new time series we plan to analyze the ecological role of humpback whale predation in PWS, particularly with respect to the depleted Pacific herring population.

Public Attitudes Towards Climate Change in Alaska: Implications for Educational Practice

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As the so called 'Climategate' controversy in 2009 once again demonstrated, there is a relatively low level of climate science literacy and a general lack of trust in climate change science amongst the media and general public. As a consequence, there is great potential to obfuscate climate science education efforts. Additionally, there have been relatively few examples to date of successful climate science education that measurably improves public understanding of climate change science.

As part of a national initiative to better understand the potential role of aquaria in climate science education (see http://www.aquariumsandclimate.com/), the Alaska SeaLife Center (ASLC) initiated a pilot series of baseline surveys of public attitudes towards climate change in Alaska in the summer of 2010. Samples were drawn equally from ASLC staff, ASLC visitors and the public of Seward. Clearly, there is a high level of awareness and concern about climate change - 95% of ASLC staff, 83% of Seward residents and 71% of ASLC Visitors believe that climate change has already impacted or will impact their lives.

However, as may be expected, there is considerably more variation in responses regarding the causes and consequences of climate change and regarding institutional and individual response options. Results are being used to shape climate change messaging in ASLC exhibits, to inform education and outreach programs and to better frame behavioral research initiatives in the ASLC and wider national aquarium community.

FIELD KIT FOR THE ONSITE DETECTION OF DOMOIC ACID

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Domoic acid (DA) is a potent toxin produced by some Pseudo-nitzchia and is responsible for amnesic shellfish poisoning in humans. Collection of shellfish in Alaska occurs along an immense region. This limits the effectiveness of Alaskan monitoring programs due to the delay between shipment and analysis. This poster describes an enzyme linked immunosorbent assay (ELISA) for detecting DA. The assay can be performed at the point of sample collection, e.g., on a beach or boat.

During evaluation in Alaska, the test was performed by a variety of groups. Briefly, a sample extract is diluted and placed on a membrane filter that responds to the presence of DA. A colored pattern is produced on the white membrane similar to a home pregnancy test. The limit of detection is approximately 2 ppm. The use of two monoclonal antibodies and an internal control eliminates the need to run a standard curve. Concentrations of DA are estimated by comparing the color response to a reference chart. Participants tested samples that were collected from a variety of species. All field samples collected during this project had low levels of DA. All sample extracts were spiked with DA to evaluate positive results as well as test for possible matrix interferences. The assay is specific for DA and no matrix interference was observed among the species tested. The low cost, simplicity, sensitivity, and rapid analysis time provided by this assay make it useful to a variety of groups interested in monitoring DA concentrations in environment samples.

A model for partnering with interns that enhances and expands ongoing research programs

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Research projects are limited to what can be accomplished within the constraints of budget and time. During most studies ancillary questions inevitably arise that are outside these constraints, even though their answers may clarify project results. Today's undergraduates are often qualified to pursue these sorts of questions when given appropriate guidance. These students are anxious for hands on opportunities and are often thrilled to have the chance to be a member of a research team. We have harnessed this desire and directed students in short-term research projects that have generated new ideas, given us new tools and provided greater detail for ongoing analyses of forage fish bioenergetics. In this presentation we describe our experience partnering with interns and describe how our research has been enhanced through these partnerships. First, we describe how we have used interns to explore ideas or datasets that could not be adequately examined under our existing workload. Second, we describe how we have used interns to develop new tools for conducting research. Finally, we show both of these modes can be combined with multiple interns so they can function as a research team. The key to our success is that while the interns are treated as full-fledged members of our research group we are mindful that we are their mentors. Many outreach programs have uncertain outcomes and therefore busy scientists are often reluctant to participate. The outreach model we describe offers scientists a demonstrable benefit while at the same time stimulating the next generation of scientists.

Habitat Provenience

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Habitat Provenience is a new method for assessing subsistence vulnerability to climate change. Developed by Sepez and Ortiz at the Alaska Fisheries Science Center as part of the NPRB's Bering Sea Integrated Ecosystem Research Program, the method was developed from subsistence harvest data from five NPRB partner communities in the Bering Sea and Aleutian Islands. By assigning the edible weight yield of each subsistence resource proportionally to the habitat types on which the organism depends during its life cycle, the community's subsistence pattern can be expressed in terms of the habitat types that support it. Five habitat types were identified, including: ice, terrestrial, freshwater, marine, and intertidal. Vulnerability of the current foraging pattern to climate change factors can then be further assessed by assigning quantitative values to the different habitat types depending on the expected intensity of climate change effects and multiplying these by the weights harvested from each habitat provenience. For example, ice habitat is expected to be most impacted under various climate change scenarios, so communities whose subsistence harvesting shows the highest level of ice-related habitat provenience are predicted to show the most climate change effects on subsistence harvest patterns. Each community shows a unique habitat provenience and patterns may be observed by comparing habitat proveniences along a latitudinal gradient. The method is currently being refined and the authors are interested in feedback from NPRB natural scientists and subsistence hunting and fishing community members.

VALIDATION OF AN IMMUNOASSAY FOR THE DETECTION OF DOMOIC ACID

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Domoic acid (DA) is a toxin produced by some Pseudo-nitzchia and accumulates in the tissue of algae feeders. Harvest of shellfish containing DA at concentrations above 20 ppm is dangerous and prohibited. The current method for the measuring DA uses HPLC, a technology that has limitations in monitoring programs. This poster presents the validation study of a rapid, sensitive enzyme linked immunosorbent assay (ELISA) for the improved detection of DA.

This competitive ELISA uses an enzyme-DA conjugate to measure the fraction of antibody binding sites that are occupied by DA. Quantitation is achieved by comparing the assay response with a calibration curve. The assay limit of detection is approximately 4 ppm. Up to thirty-six sample extracts can be analyzed simultaneously in approximately 1.5 hours. Seven species of shellfish were collected from a wide range of locations in Alaska for this study. Samples were analyzed both unspiked and spiked with DA at various concentrations. Studies were designed to measure accuracy, precision, recovery, specificity, ruggedness, and correlation with FMOC-HPLC. The ELISA is specific for DA and does not cross-react significantly with glutamate or glutamic acid. All species tested showed no matrix interference. Correlation with HPLC was excellent. Spike recovery averaged 95%. Correlation coefficients of replicates were approximately 15%, normal for ELISA assays. The relatively low cost and rapid analysis time provided by this assay make it useful to environmental managers and public health officials for monitoring DA concentrations in environment samples. Approval for regulatory use is pending.

Examination of toxicological biomarkers for petroleum exposure in arctic cod, *Boreogadus saida*, from the Chukchi Sea: results from the COMIDA program

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With the growing interest in oil exportation in the Arctic Ocean, there is a crucial need to carry out baseline mapping of the types and numbers of species in these locations prior to drilling. In addition, to also determine the baseline health status of representative organisms using biomarker endpoints that are known to respond following exposure to oil. This will allow more accurate assessments of potential impacts of future oil usage on these arctic ecosystems. As part of the COMIDA project, we analyzed three common biomarkers for exposure and effects of petroleum polyaromatic hydrocarbons (PAHs) in arctic cod, *Boreogadus saida*, collected during 2010 sampling in the Chukchi Sea. A total of 24 arctic cod from 6 sites (7.2-14 cm) were chosen for analysis with parallel sampling of particles and sediments for organic contaminant analysis. Fish were dissected and tissues/blood collected for various assays onboard (e.g. DNA damage COMET assay) with additional tissues frozen and stored in liquid nitrogen until processing in the laboratory. To assess exposure to PAHs, the gene expression and enzymatic activity of cytochrome P4501A, and the common antioxidant enzyme, glutathione-s-transferase, are being measured in fish liver tissue. To assess the effects of PAHs, DNA damage is being measured using the Comet assay for both fish liver and blood samples. Results of toxicological data will be compared with hydrocarbon burdens measured in corresponding fish muscle tissue. Results of varying fish species and size will compare chemical burdens and toxicological response to determine their sensitivity to PAHs as well as the critical timing of exposure and toxicity levels throughout different life stages.

At Risk

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Many organizations, including the Monterey Bay Aquarium, Green Peace, and the IUCN, publish lists of fish species not to eat, either because their populations are on the brink of collapse or the fishing methods used to extract them from the ocean are harmful to the surrounding environment. Educating the public about struggling fish populations and inspiring people to simply avoid those species could greatly reduce their demand.

In my poster I will paint the species of fish that have been “red listed.” Many people buying tuna in a can or frozen shrimp have little concept of how majestic these creatures are, alive and swimming in the ocean. I think that a poster displaying these fish, swimming amongst each other in all their beauty will really help everyone understand that their tuna sandwich and shrimp cocktail are more than just items in the supermarket, they are living players in the vast ocean ecosystem, and they deserve a break. My poster will show the relationship between the terrestrial environment, the aquatic environment and all the creatures living within them, both human and non-human.

Visual and acoustic survey results during the 2010 CHAOZ cruise

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The combination of visual observations and passive acoustic monitoring is extremely useful for evaluating the short-term distribution and movements of marine mammals. Sonobuoys are perfectly matched to visual transect surveys because they can be deployed while underway, can be monitored for 15 or more miles, and provide excellent recordings of all vocalizing marine mammals (especially baleen whales). These visual-acoustic surveys complement data obtained by long-term moored recorders by allowing for a larger coverage area. As part of the first CHAOZ (CHukchi Acoustic, Oceanographic, and Zooplankton study) cruise (24 Aug – 20 Sept, 2010), daytime visual observations and near-24 hour passive acoustic monitoring (sonobuoys) were conducted. A total of 1,478 miles were visually observed, and 102 sonobuoys were monitored during the cruise which worked the area between Nome and Barrow, Alaska. Results from the visual observations include a total of 139 sightings (53 cetacean, 86 pinniped) of 12 confirmed marine mammal species, as well as an additional 96 sightings (17 cetacean, 79 pinniped) of unidentified marine mammals. The most common species acoustically detected were *Balaenoptera physalus*, *Megaptera novaeangliae*, *Odobenus rosmarus*, and *Balaena mysticetus*. However, the most common acoustic detections were seismic airguns, detected on over 37% of the buoys (38 of 102). All airgun detections occurred between 69-72°N and 156-168°W. This area also had a limited number of cetacean visual/acoustic detections, although pinniped species were scattered throughout. [Work supported by the Bureau of Ocean Energy Management, Regulation, and Enforcement]

Bringing CHAOZ to the Arctic

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The physical climate of the Pacific Arctic is rapidly changing. Recent extremes in the minimum extent of summer sea ice has created opportunities for the expansion of oil and gas-related exploration and development in the Chukchi and Beaufort seas. This combination of increasing anthropogenic impacts coupled with the steadily increasing abundance and related seasonal range expansion of bowhead, gray, humpback, and fin whales, predicates the need for current information on the year-round presence of large whales, especially in the Chukchi Sea planning area. In 2010, the NOAA Alaska Fisheries Science Center (AFSC) and the Pacific Marine Environmental Laboratory (PMEL) entered into a multi-year Inter-Agency agreement with the Bureau of Ocean Energy Management, Regulation, and Enforcement (BOEMRE/MMS) to document the distribution and relative abundance of whales in areas of potential oil and gas exploration and to relate changes in those variables to oceanographic conditions, indices of potential prey density, and level of anthropogenic activities. The first CHAOZ (CHukchi Acoustic, Oceanographic, and Zooplankton) cruise was conducted on board the F/V Alaskan Enterprise from 24 Aug-20 Sep 2010. A total of 15 passive acoustic and 7 biophysical moorings were deployed in three arrays off Icy Cape. In addition, 50 hydrographic and zooplankton stations were conducted along five transect lines (Point Hope, Cape Lisburne, Point Lay, Icy Cape, and Wainwright) and in the Bering Strait. Over 1,750 miles were surveyed by visual (marine mammal and bird) observers and monitored by passive acoustic technicians, via sonobuoy deployments every three hours.

Effects of airgun sounds on bowhead whale call detection rates

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The effect of sounds from airgun pulses on bowhead whale calling behavior was assessed during the whales' autumn migration in 2007. During the open-water season (Aug–Oct), 35 directional autonomous seafloor acoustic recorders (DASARs) were deployed at 5 sites in the Alaskan Beaufort Sea. Over 168,000 bowhead calls were detected and location estimates were obtained for >137,500 of these calls. Analyses were conducted on a subsample of calls that had high detection probability. Background sound and other naturally varying factors were either small or controlled by the analysis. Call location rates (i.e., detection rates of localized calls) were compared before, during, and after periods of airgun use between sites that were near seismic activities (median distance 41–46 km) and sites that were far from seismic activities (median distance >104 km). Bowhead call location rates dropped significantly ($p<0.001$) at the onset of airgun use at the sites near the airguns, where median received levels from airgun pulses were ≥115 dB re 1 µPa (SPL). Call location rates at sites far from the airguns, where median received levels were <107 dB re 1 µPa, did not change. This drop in call location rate could be due to a cessation of calling activity, or deflection of whales around seismic activities, but call locations alone are insufficient to differentiate between these possibilities. Reverberation from airgun pulses could have masked a small proportion of calls at locations near the airguns, but cannot explain results of the study.

Eastern North Pacific Gray Whale Distribution and Habitat Use in the Chukchi Sea from Aerial Surveys: 1982-1991, 2008-2010

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Marine mammal aerial surveys were conducted in the northeastern Chukchi Sea (68-73°N, 157-169°W) from June to October 1982-1991. Renewed interest in oil and gas activity in this area provided the impetus for the surveys to recommence in 2008; the recent surveys are part of the Chukchi Offshore Monitoring in Drilling Area (COMIDA) project, funded by the Minerals Management Service. These broad-scale surveys have documented the distribution of the Eastern North Pacific stock of gray whales on summer feeding grounds in the Chukchi Sea. Arctic waters comprise the northernmost part of their range, which extends southward along the west coast of North America down to wintering areas off California, the Baja Peninsula, and in the Gulf of California. Gray whales in the Chukchi Sea have been found in high densities in three different areas. First, the greatest number of gray whales (which have occurred during all months surveyed) were nearshore between Point Barrow and Point Lay. Second, gray whales were consistently seen in the area offshore of Point Hope in spite of relatively little survey effort in that area. Third, in autumn of 1989-1991, there was a high density area offshore over Hanna Shoal; however, few gray whales were seen in that area in autumn of 2008-2010. The recent lack of summer sea ice in the Chukchi may be affecting the location of high densities of prey, and hence the distribution of gray whales. Gray whale calves have been sighted mostly in nearshore shallow areas.

Comparison of Three Diet Analysis Methods within Individual Bearded Seals

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Multiple methods are currently used to analyze diets of seals including stomach contents, stable isotopes, and fatty acids. This study assesses the differences in the dietary information resulting from each of these methods within individual bearded seals (*Erignathus barbatus*). While all of these methods are useful, there are aspects of each that need to be evaluated in order to yield the most informative results. Stomach, muscle, and blubber samples were collected from eight adult bearded seals (4 males and 4 females) harvested for subsistence near Point Hope, Alaska in June 2007 and 2008. Fish identified from hard parts in stomachs included sand lances (25% frequency of occurrence), cod (75%), sculpins (88%), pricklebacks (25%), and flatfish (63%). Invertebrate prey included sponges (25%), mollusks (38%), and shrimp, crab, and echiurids all at 63%. Stable nitrogen isotopes in muscle had a range of 15.14 – 17.31‰ indicating foraging at multiple trophic levels. While stable isotopes provide information on assimilated prey over a longer time frame, they provide poor taxonomic resolution. Seventy-six fatty acids were identified in the blubber and used to determine prey items consumed and assimilated, however, modification of the fatty acids ingested by the seal as well as differential use of fatty acids within the blubber layer make results difficult to interpret. Investigating these three methods simultaneously in the same individual seals will aid marine mammal diet research by providing specific information for researchers to determine which method or combination of methods are best suited for their particular studies.

Can we hear Cook Inlet Beluga whales feeding?

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Specific echolocation signals during foraging have been described in several odontocetes, including narwhals, but not yet for belugas. If specific beluga echolocation signals are indicative of foraging, acoustic monitoring would help determine the temporal and spatial occurrence of foraging and would thus make an important contribution to the conservation and management of the endangered Cook Inlet (CI) population. With the aim of describing the production of context-specific click trains by foraging CI belugas, a pilot study was conducted August-September 2010 to record CI beluga acoustic behavior concurrently with visual observations. Paired boat-based and land-based recordings were obtained in open waters, as well as inside Eagle River (Knik Arm). Acoustic recordings were made with a wideband (0-500 kHz) single channel recorder and a deployable recording package (DSG-Ocean, Loggerhead Instruments ltd.). More than 9 hours of recordings in the presence of belugas were collected. Acoustic behaviors differed significantly when classified by surface behavior. During presumable feeding or prey search, social calls were absent and echolocation clicks often occurred in train packets (a behavior only described while performing target experiments on captive belugas). Burst pulses were also found more often, although few of these were conclusively categorized as terminal buzzes related to prey capture since most of the events were partially incomplete, lacking part of the initial click train structure described in other feeding odontocetes. These results indicate that the acoustic behavior of CI belugas is modified when feeding and has the potential to be used as an indirect indicator of foraging behavior.

Pacific Walrus Sightings Documented by COMIDA Aerial Surveys of the Northeastern Chukchi Sea in 2010

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In 2010, the National Marine Mammal Laboratory (NMML) (NOAA Fisheries), through an interagency agreement with the Minerals Management Service, conducted aerial surveys in the northeastern Chukchi Sea as part of the Chukchi Offshore Monitoring in Drilling Area (COMIDA) project. The surveys, which have been conducted annually by NMML since 2008, were designed to document the distribution of marine mammals in the northeastern Chukchi Sea during the ice-free months (June-October). Surveys were conducted from July 1 to October 27, from 72°N to 68°N between 169°W and 157°W. A total of 44 flights were conducted over 188 survey hours. Pacific walruses (*Odobenus rosmarus*) were widely distributed throughout the survey area and were observed in all months of the study period. Excluding known duplicate sightings of haul outs, NMML recorded 314 walrus sightings comprising 26,688 individuals. In July and August, walruses were observed in open water or hauled out on sea ice. On August 30, the first haul outs on land were documented, one located 3 miles northeast of Point Lay and three located 22 miles east of Cape Lisburne. The Point Lay haul out was observed on five subsequent surveys between September 6-24; group size estimates of the haul out varied between days and ranged from 800 to 15,000 individuals. Additional surveys were conducted near Point Lay from October 8-25 but no haul outs were sighted. The increase in walruses hauled out on land in the fall is likely a result of the lack of sea ice in the northeastern Chukchi Sea.

Seasonal occurrence of bowhead whale (*Balaena mysticetus*) calls in the Northeastern Chukchi Sea, 2006-2009

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Bowhead whales (*Balaena mysticetus*) are found throughout the arctic and are closely associated with sea ice much of the year. To observe the seasonality of offshore bowhead whale distributions, we collected and analyzed autonomous passive acoustic data at an offshore site 120 km NNW of Barrow, Alaska in the Chukchi Sea. Between 2006 and 2009, a High Frequency Acoustic Recording Package (HARP) was used for data acquisition and a detection database was produced by visually scanning spectral-averaged acoustic data for whale calls. Call types were determined by frequency and duration. Bowhead whale calls were classified and logged into eleven different categories: up sweep, down sweep, up sweep with harmonics, “u” call, “u” call with harmonics, “n” call, “n” call with harmonics, “Oo” call, pulsed call, constant call and song. We found that pulsed calls were the most common (36% of total detections). Most bowhead acoustic detections occurred between September and October, as well as from April to May, which are the known migration periods. An unexpectedly large number of calls also were detected during the winter months.

Data analysis was carried out by students at Mt. Edgecumbe High School (MEHS) in Sitka, Alaska, as part of the SeaTech program. SeaTech is a research internship and technology training program at MEHS where students collaborate with researchers from the Whale Acoustics Laboratory at the Scripps Institution of Oceanography (SIO). The program consists of an oceanography course, as well as the opportunity to conduct independent research projects and present results at SIO in California.

Stomach content analysis reveals temporal changes of ice seal diets in Alaska: Climate change or regime shift?

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Recent studies have predicted how changes related to climate warming may impact Arctic marine food webs. We examined stomach contents of spotted (*Phoca largha*), bearded (*Erignathus barbatus*), and ringed seals (*Phoca hispida*) harvested in the Bering and Chukchi seas of Alaska (1960–2009) and used logistic regression to test for temporal changes in the frequency of occurrence of prey items. Stomach contents from 1,919 seals collected in the 1960s and 1970s were compared with 1,064 collected since 2000. All species consumed fish more frequently during the 2000s than in the 1960s and 1970s. Specifically, flatfish (Pleuronectidae), arctic cod (*Boreogadus saida*), saffron cod (Eleginus gracilis), and walleye pollock (*Theragra chalcogramma*) were consumed more frequently by all seals in the 2000s and this corresponded with a general decrease in consumption of invertebrates (i.e., mysids, amphipods, and shrimp). Our analysis showed that significant changes in diet can be detected by analyzing stomach contents. Some of the changes we detected (e.g., increases in benthic and demersal fish, and increases in arctic cod in the Bering Sea) are better explained by a regime shift than by climate change. Given recent concerns regarding the status of ice-associated pinnipeds due to climate change, loss of habitat, and the relative time scale of these changes, long-term stomach content datasets will be an increasingly valuable source of information for assessing changes in prey distributions and pinniped feeding ecology, however we need to evaluate possible mechanisms causing these changes, including regime shifts.

Polar bears in a sea of change: 36 years of observations from a barrier island in the Beaufort Sea

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The barrier islands of the Alaskan Beaufort Sea have been included in a proposed designation of polar bear critical habitat following the listing of that species as “threatened” under the Endangered Species Act. The continuing decline of summer sea ice has been considered the primary factor leading to the increased bear occurrence on these islands but most supporting evidence has been incidental and lacked a decadal perspective and behavioral observations. A unique time-series has been obtained at Cooper Island, a barrier island 30 km east of Point Barrow, where observations of polar bear summer occurrence and activities have been obtained annually since 1975 during the course of seabird research.

Polar bear occurrence has increased greatly in recent years, with bears being seen on only five of the 27 years from 1975 to 2001 but on eight of the nine years since then. Preliminary analyses indicate this increase in occurrence is related to the reduction of adjacent sea ice, with the ice concentration at the shelfbreak on August 15 as the best predictor for the occurrence of bears on the island. Bears occurred in only 13 percent of the years when ice cover at the shelfbreak was >40 percent but in 83 percent of the years when shelfbreak ice concentration was <40 percent, indicating bears remain with the ice until it leaves the shelf. Bear behavior has changed as well, with bear visits typically <2 days before 2002, but now regularly >3 days while they sleep and forage on the island.

A long-distance swimming event by a female polar bear during an extreme summer sea ice melt season in the Beaufort Sea

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Between 26 August and 4 September 2008, a radio-collared adult female polar bear (*Ursus maritimus*) swam 687 km through ice-free waters north from the Alaskan Beaufort Sea coast to offshore pack ice. The bear then intermittently swam or walked on the sea ice surface an additional 1800 km until her recapture on the Beaufort Sea coast on 26 October 2008. During the 687 km swim, collar activity sensors and GPS data showed that the bear swam continuously without rest for 232 hours. Her body temperature declined during the 9 day swim. Between her first capture (23 August 2008) and later recapture she lost 22% of her body weight and lost her yearling cub. This observation demonstrates the extraordinary ability of polar bears to swim long distances of open ocean and their fidelity for sea ice. The observation also suggests that long distance swimming in Arctic waters, and travel over deep water pack ice, may incur high costs in terms of individual health and reproductive fitness. If projected trends of sea ice loss in the 21st century are realized the frequency of long distance swimming by polar bears may increase. This behavior may have negative impacts on polar bear populations.

Why Bowhead whales (*Balaena mysticetus*) need sea ice

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Large-bodied marine mammals, like the bowhead whale (*Balaena mysticetus*), are adapted to life in Arctic environments. We tested whether the bowhead whale makes use of seasonal variation in the sea ice environment by seasonal migration. Twenty-seven bowhead whales from the Eastern Canada-West Greenland (EC-WG) population were tagged with satellite transmitters in Nunavut, Canada, 2002-06, that provided location information used to calculate movement rate and habitat use. Using a quantitative approach, we demarcated two seasons based on movement rate changes for bowhead whales: winter (28 December – 15 March, 16.6±2.65 km/d) and summer (27 June – 27 December, 31.9±1.05 km/d). Next, we used resource selection functions to evaluate bowhead seasonal selection of three landscape views of sea ice (coverage, thickness, and floe size) throughout their annual range. The highly variable sea ice landscape cycles from near complete coverage in winter to near complete absence of sea ice in summer. The EC-WG population is characterized by considerable sexual and reproductive segregation in seasonal habitat use and as a consequence movement and habitat use differed between tagging sites. Overall, whales selected (1) low ice coverage areas in winter presumably to reduce risk of ice entrapment whereas (2) high ice coverage areas were preferred in summer, presumably to reduce risk of killer whale predation and provide enriched feeding opportunities. Similarly, whales selected low ice thickness and small floe size areas in winter with the opposite pattern evident in summer. Our results confirm the predicted pattern of a large-bodied animal that can make use of the large-scale seasonal fluctuations in seasonal sea ice typical of polar environments.

Modeling the Potential Habitat for Gray Whales Throughout the Northern Hemisphere

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Gray whales (*Eschrichtius robustus*) were once plentiful in the Northern Hemisphere along the coasts of the Pacific and Atlantic oceans. The whales became extinct in the Atlantic over 200 years ago and their numbers were reduced in the Pacific during the 19th and 20th centuries. With bans on hunting whales, the eastern Pacific gray whales once again number in the tens of thousands. Recently a gray whale was spotted in the Mediterranean. With the opening of a northwest passage around North America questions of whether gray whales can reestablish themselves in the Atlantic and which areas are important for conservation are of interest. We modeled the potential distribution of the whales throughout the northern hemisphere using the available observations for the eastern Pacific population, environmental layers, and a new spatial modeling technique. The spatial modeling approach uses n-dimensional envelopes to model a species in environmental space. Bathymetry and sea surface temperature (SST) were used as predictor variables to model the potential habitat during each of the 12 months of the whales annual migration from mid-latitude breeding grounds to northern feeding grounds. Most months produced Area Under the Curve (AUC) measures of greater than 0.9. The model was then applied to the entire northern hemisphere as an initial step in modeling their habitat in the western Pacific and the Atlantic. The model correlated with some known locations of whales in the western Pacific but missed others. The model for the Atlantic showed large areas of potential habitat for the whales and may be an early indicator of areas to consider for conservation efforts.

Distribution, Relative Abundance and Behaviors of Bowhead Whales in the Alaskan Beaufort and Northeastern Chukchi Seas - Autumn, 2007-2010

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Broad-scale aerial surveys for marine mammals were conducted annually under the auspices of COMIDA (Chukchi Offshore Monitoring in Drilling Area) and BWASP (Bowhead Whale Aerial Survey Project), sponsored by the Minerals Management Service. Survey objectives included determining the autumn (September and October) migration path, relative abundance, and behavior of bowhead whales (*Balaena mysticetus*). The combined survey area extended from 140°W to 169°W and 68°N to 72°N, and was divided into 22 survey blocks. Bowhead distribution and relative abundance were summarized based on survey blocks and depth zones. Results were limited to 2007-2010, corresponding to data collected since summer sea ice extent was at historical minimums. Bowhead distribution in the Alaskan Beaufort Sea was relatively close to shore and, based on sighting rate, habitat preference was strongly associated with the inner continental shelf (≤50 m depth zone). In the northeastern Chukchi Sea, distribution was southwesterly from Pt. Barrow. Highest sighting rates were in blocks 13 and 18, with sighting rates highest in the outer continental shelf (51-200 m depth zone). Feeding and milling (which may be indicative of feeding) were recorded across the Beaufort Sea, but seen only once in the Chukchi Sea. Mating behavior was also observed in one group of four whales located in the Beaufort Sea. A total of 53 calves were sighted.

Assessment of high resolution ultrasound imaging as a noninvasive measure of blubber thickness in beluga whales (*Delphinapterus leucas*)

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Cetacean blubber is important for thermoregulation, buoyancy/streamlining, and energy storage. Blubber is also used as a proxy to determine body condition and energy stores in an animal. Blubber biopsies are the accepted method to determine blubber thickness in cetaceans. However this method is invasive and typically entails only one or two measurements per animal. Ultrasound technology is a non-invasive alternative to biopsy that has been demonstrated as an accurate alternative to measure blubber thickness of pinnipeds and large whales. This method allows many more locations on the animal to be sampled, which provides a more precise estimate of whole-body energy stores. The purpose of this study was to determine if high resolution ultrasound technology provides is a precise and accurate method for measuring blubber depth of beluga whales (*Delphinapterus leucas*). Blubber depth was measured using a ruler and ultrasound on samples collected from the subsistence hunt in Point Lay, Alaska in 2009 and 2010. Ruler measurements and ultrasound measurements were performed by different individuals in order to prevent bias in the measurements. Both measurements were compared using simple linear regression. High resolution ultrasound imaging was 87.0% accurate at predicting ruler measurements at the same location. These results confirm that high resolution ultrasound imaging is a viable alternative to biopsy in beluga whales.

Seasonal presence of ringed (*Pusa hispida*), ribbon (*Histrophoca fasciata*), and bearded seal (*Erignathus barbatus*) vocalizations in the Chukchi Sea, north of Barrow, Alaska

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Long-term autonomous acoustic recordings were collected between September and June from 2006 through 2009 in the Northeastern Chukchi Sea along the continental slope about 120km north-northwest of Barrow, Alaska. These recordings were analyzed for the presence of vocalizations of ringed seals (*Pusa hispida*), ribbon seals (*Histrophoca fasciata*), and bearded seals (*Erignathus barbatus*). We present detailed descriptions of the acoustic repertoire of each species in addition to a three-year time series of seal vocalizations and mean daily sea ice concentration. Ribbon seal calls occur only during the open water period in 2008 and their acoustic behavior is more varied than previously described. Ringed seal vocalizations are present throughout each winter and spring, indicating that they are both overwintering and breeding in offshore pack ice. Bearded seal vocalizations closely match well-documented calls recorded offshore near Point Barrow, but have shorter duration and smaller frequency range, suggesting that demographic or behavioral differences related to breeding habitat selection may exist within the population. Bearded seal calls peak during the breeding season from March through June, but also occur in December and January of all years. These long-term autonomous recordings provided details of seasonal distribution and behavior of Alaskan Arctic seals that previously have not been possible to observe with other methods.

Baseline Histological Health Assessment of Subsistence Harvested Arctic Marine Mammals from the North Slope Borough Villages of Barrow and Wainwright, Alaska

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Routine histological analysis of formalin- fixed tissues obtained from subsistence harvested seals and walruses taken near the North Slope Borough villages of Wainwright and Barrow, Alaska was conducted in order to survey these important subsistence resources for evidence of contaminant exposure, disease surveillance and infection with zoonotic pathogens. Mild exertional rhabdomyolysis with loss of sarcoplasmic detail, fragmentation, myositis, repair and healing was consistently observed. Sarcocysts were identified in the skeletal muscles of seals, but not walruses. Endoarteritis in ringed seals with moderate to severe fibromuscular intimal proliferation, fragmentation of the internal elastic membrane, and thrombi formation indicative of *Acanthocheilonema spirocauda* infection was repeatedly observed. *Parafilaroides* spp were positively identified in sections of lung from ringed seals and were implicated in the presence of verminous pneumonia in bearded seals. A consistent finding among all sections of liver examined from seals and walruses was focal areas of hypertrophied Kupffer cells, occasional neutrophils and lymphoplasmacytic infiltration suggestive of parasitic migration through the liver parenchyma. Positive identification of eggs and flukes consistent with *Orthosplanchnus* spp. infection along with moderate to severe chronic active cholangitis, cholangiohepatitis and hepatocellular necrosis caused by fluke presence was a common finding. The same flukes were responsible for inflammation and fibrosis of the pancreatic ducts and periportal fibrosis. One seal had a focus of severe chronic granulomatous pancreatitis with focal peritonitis. There was no histopathogical evidence of renal colonization with *Leptospira* spp. Histological evidence of immunosuppression or endocrine disruption associated with environmental contaminant exposure was not observed.

The importance of marine resources and sea ice to the Arctic fox

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Stable isotope analysis of carbon and nitrogen can provide a diet history for an organism over different time frames. They can also be used to distinguish between terrestrial and marine sources of input into diet. For a species that can utilize both marine and terrestrial sources of food such as the Arctic fox (*Vulpes lagopus*), stable isotope analysis can provide information regarding the use of different habitats including sea ice. During fall 2009, Argos satellite radio collars were placed on Arctic fox in the Prudhoe Bay Oilfield (PBO) and the National Petroleum Reserve-Alaska (NPR-A). Fox movement was tracked throughout the winter and into spring. Arctic fox winter movement and diet were compared between the PBO and the NPR-A. Bone collagen and muscle from collected foxes were analyzed using stable carbon and nitrogen isotopes to determine winter diet and detect marine sources of input into diet. Within NPR-A, foxes traveled greater total distances and had higher daily travel rates than foxes in the PBO. Of the foxes collared in NPR-A, 27% used the sea ice for extensive periods of time over the winter, but 0% for Prudhoe Bay foxes. However, stable isotope analysis of bone collagen from all foxes suggested only terrestrial sources of input into diet (δ15N collagen values ranged from 6.09 to10.76 ‰ and δ13C collagen values ranged from -23.10 to -19.82 ‰). Of the foxes that were known to have used the sea ice based on telemetry data, none could be recovered and analyzed due to logistical constraints. Although stable isotope ratios suggest that the majority of dietary items is of terrestrial origin, and this may be inherently biased due to collection constraints, marine resources and sea ice are of importance to Arctic foxes.

Year-round passive acoustic monitoring of bearded seal vocalizations at two locations in the Beaufort Sea

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Bearded seals (*Erignathus barbatus*) are a pan-Arctic species that are relatively abundant and widely distributed in the high north. In the Beaufort Sea, bearded seals occur mostly on pack ice, migrating with the advance and retreat of the ice front through the Bering Strait. Bearded seals are known for their long loud trills that are produced primarily in the spring and are believed to be a male reproductive display. Most work on bearded seal acoustics has taken place during spring months as this is when the seals are most vocally active. Here we present data on the occurrence of bearded seal vocalizations from September 2008-August 2009 from two locations 150 km apart in the western Beaufort Sea. Passive acoustic data were collected using hydrophone packages (Multi-electronique Aural M-2) that had an effective bandwidth of 10-4000 Hz and a duty cycle of 9 min on every 30 min. The instruments were moored on the 100 m contour and suspended 5 m above the sea floor. Bearded seal vocalizations were initially detected automatically and then manually checked for verification. Both sites showed that bearded seals were vocally active year-round with the greatest number of vocalizations in the spring, coinciding with mating season, and fewest calls detected in August. Comparisons of vocal activity between sites, with ice cover, water temperature and time of day will be presented.

Results from the 2010 BOWFEST Aerial Survey off Barrow, Alaska

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The Bowhead Whale Feeding Ecology Study (BOWFEST) was established to determine the scale and factors relevant to feeding ecology of bowhead whales in summer near Barrow. Aspects important to this study are the consistency of bowhead feeding behavior relative to location, year, and age class (using whale size as a proxy for age). Accordingly, the aerial survey component of BOWFEST has been designed to document patterns and variability in the timing and locations of bowhead whales as well as provide an estimate of temporal and spatial habitat use. Using a NOAA Twin Otter, scientists from the National Marine Mammal Laboratory conducted aerial surveys over most of the BOWFEST study area (continental shelf waters between 157° W and 152° W and from the coastline to 72° N). All flights were based out of Barrow with most of the effort concentrated within 40 km of the coastline. In 2010, flights were conducted on 8 days between 31 August and 18 September, for a total of 33 flight hours, compared to 31 hrs in 2007, 43 hrs in 2008, and 18 hrs in 2009. There were 102 sightings of bowheads (an estimated 383 whales), compared to 16 sightings (49 whales) in 2007, 56 sightings (163 whales) in 2008, and 29 sightings (51 whales) in 2009. In all years, many of the bowheads were described as feeding, and “traveling” was the most commonly recorded behavior, indicating that bowheads were most likely migrating through the study area, seemingly on a feeding migration.

Advanced techniques for improving aerial photography of whales

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Aerial photography is used to obtain information on residence times, feeding behavior, and age classes of whales. Prior to 2010, as part of the Bowhead Whale Feeding Ecology Study (BOWFEST), researchers from the National Marine Mammal Laboratory (NMML) used a single camera with a 50mm lens in a forward motion compensating (FMC) mount (with a rocker mechanism to counter the forward velocity of the aircraft) for photogrammetry and a handheld camera with a 70-200mm zoom lens for photo-identification. Both cameras were aimed out of a large belly window. In 2010, a fully automated, triple-camera system in a FMC mount replaced the single FMC mount and hand-held camera. This new system provided a larger photographic footprint with slight overlap between images horizontally and 60% overlap vertically (along the flight line). Although the new triple camera system (Canon EOS-1DS Mark III cameras with Zeiss 85mm f1/4 lenses) gave us a larger field of view, the lower magnification of the lenses (85 vs. 200mm) provided smaller images of whales (i.e., lower quality for photo-identification). Only the center camera is used for photogrammetry. Before 2010, altitudes were recorded from an autonomous radar altimeter (Honeywell AA300 model) and a GPS (Global Positioning System) with a built-in barometric altimeter. In 2010, a laser altimeter (Universal Laser Sensor) was added, providing altitudes precise to within a few centimeters. The laser, radar, and GPS altimeters were tested over a calibration target, which provides a correction factor for whale body length estimates relative to aircraft altitude.

Infectious Disease Concerns in Marine Mammals of the Circumpolar Arctic

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Marine mammals are an important subsistence food source for the people living in the circumpolar arctic. Increasingly, user groups and scientists are becoming concerned about infectious diseases capable of significantly decreasing the number of healthy animals available for hunting as well as concerns regarding diseases that be transmitted to and cause disease in humans. Increased human activity in the north associated with oil and gas activity, and climate change are exacerbating the “stress” that marine mammals are subjected to; making them less suited to growth and survival in this new changing environment. Decline in the individual health of some animals and the failure of some stocks to thrive maybe related to a number of contributing factors; including mortality caused by infectious diseases but the linkages to these effects are still unclear. Introduction of marine distemper viruses into populations of susceptible animals not previously exposed to these viruses represents the greatest threat of die-offs of marine mammals in the near term, while chronic diseases affecting reproduction such as brucellosis may cause population declines over a period of decades as well as negatively affecting the health of individual infected animals. New molecular genetic sequencing technologies coupled with more traditional virus isolation and serology testing methodologies show promise in identifying new viral threats emerging in sea otters (*Enhydra lutris*), Steller sea lions (*Eumetopias jubatus*) and beluga (*Delphinapterus leucas*) from Alaska; beluga from the Canadian Arctic Ocean and the Russian Sea of Okhotsk. Results from each geographic area will be presented.

Pacific walrus haulout attendance and disturbance via remote cameras: 2011

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The Pacific walrus is being considered for listing under the Endangered Species Act due to reductions in their sea ice habitat resulting from climate change. Walrus rely on both land and sea-ice as haulout substrate, though use is highly stratified by sex and age, particularly during summer months. Male walrus are commonly found on summer terrestrial haulouts, while females and calves primarily rely on sea-ice because it offers protection from predators and access to foraging areas. During 2007, female walruses with calves made the first notable move to Alaskan terrestrial haulouts. Female walruses again made landfall in 2009 and 2010. All three years coincided with low summer ice cover. Loss of habitat coupled with a potentially declining population pose paired threats to the long-term sustainability of Pacific walruses. The overall goals of our project are to assess attendance, duration, and level of disturbance at five terrestrial walrus haulout locations. In 2011 two digital still cameras will be mounted at each of five terrestrial Alaskan walrus haulouts. Three established haulouts located in Bristol Bay and two immerging locations on the North Slope/Chukchi Sea coast. One camera at each site will face the primary haulout to record animal abundance, duration, and reactions to disturbance. The second camera will focus on the immediate water access to the area to record potential disturbances. These camera observations are a non-invasive means to collect data for a long period of time with little to no disturbance to the study animals.

Results from Village-Based Walrus Studies in Alaska, 2010

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Walruses (*Odobenus rosmarus divergens*) winter in the Bering Sea, but females with young summer in the Chukchi Sea resting on sea ice; most adult males remain in the Bering Sea where they rest on land. The rapid retreat of sea ice is changing walrus summer habitat in the Chukchi Sea and may be changing summer distribution and haulout behavior, requiring that walruses haul out on land instead of ice. Oil and gas activity has increased, elevating the importance of understanding walrus movements, feeding behavior, and habitat requirements necessary to develop effective mitigation measures for conservation. In Alaska, some terrestrial haulouts are likely to be accessible from coastal communities. The purpose of this study is to work with subsistence walrus hunters to conduct observations, deploy satellite-linked tags to monitor movements and feeding behavior, and collect traditional and local knowledge on walruses in the Chukchi Sea. In September of 2010, a large haulout (10–20,000 walruses) formed near the village of Pt. Lay. Large haulouts are susceptible to stampedes, which cause calf mortality. Local walrus hunters documented the number and condition of carcasses accessible near the haulout, monitored the status of the haulout, and travelled the coast looking for other haulouts and carcasses. In addition, two tags were deployed on adult females near Cape Lisburne. One tag lasted a few days, but the other transmitted for 26 days, tracking a nine-day crossing of the Chukchi Sea followed by a haul out period near Cape Serdse Kamen on the Chukotka Peninsula.

Behavioural responses of bowhead whales to industrial seismic activities in the Alaskan Arctic

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Wildlife populations, such as bowhead whales (*Balaena mysticetus*), must contend with growing levels of human activity as exploitation of marine resources increases. We analyzed existing data to explore the potential effects of oil and gas exploration on bowhead whale behavior in the Alaskan Beaufort Sea, where the distribution of whales overlaps with offshore industry activities from late summer to early fall. Previous studies suggest that bowhead whales exposed to seismic survey activity exhibit localized displacement and that they alter their surface-respiration-dive (SRD) behaviors. SRD behavior of undisturbed bowhead behavior has also been shown to be influenced by age, activity, season and region. Our analysis extends these studies by investigating the influence of seismic survey activity on the SRD behavior, and hence the detectability of bowhead whales during aerial surveys. We combined behavioral data collected by government and industry aerial survey programs between 1980 and 2000 to estimate behavior needed for calculating sightability correction factors for whales observed while exposed to seismic surveys. Sightability correction factors account for the variable detectability of whales during aerial surveys and are an integral part of distribution assessments. The results of our study will improve understanding of how cetaceans respond to seismic survey activities, and may have implications for monitoring and mitigating the impacts of such operations on bowhead whales.

What's for Dinner? The Influence of Location on Pacific Walrus Feeding Ecology

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Pacific walruses (*Odobenus rosmarus divergens*) depend on Arctic sea ice for a significant part of their life history. Sea ice provides a resting and diving platform for foraging and allows walruses energetically-efficient access to benthic invertebrate prey along the continental shelf. However, it has been suggested that in situations of nutritional stress or during unfavorable ice conditions walruses may prey on other pinnipeds. It is well known that dramatic prey shifts (e.g., seal-eating) can alter host-parasite dynamics and result in declining body condition and fecundity, increased disease susceptibility, decreased offspring survival, and changes in contaminant exposure; all of which can lead to population declines. We use stable carbon and nitrogen isotope analysis and Bayesian mixing models to quantify higher trophic level feeding behavior in Pacific walruses. Results indicate correlations between sex, geographic location, and proportion of seals or similar high trophic level prey to walrus diet. Four of the 86 males analyzed displayed clear d15N signatures indicative of "seal-eating" behavior, whereas none of the 177 females analyzed provided data that implied this behaviour. These findings support traditional ecological knowledge of Alaskan subsistence walrus hunters suggesting that only male walruses eat seals. Additionally, d15N signatures of males indicate distinct variation in trophic level prey choice based on geographic location, with males from the Bristol Bay and Chukotka regions foraging at lower trophic levels than males in the Chukchi Sea and females in all regions.

Automated localization of bowhead whale calls in the presence of Beaufort Sea seismic exploration activity

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A group of software tools has been developed for automated detection and localization of bowhead whale sounds in the shallow Beaufort Sea with arbitrary frequency-modulated tones. The software is a mixture of JAVA, UNIX C-shell scripts and MATLAB components, and consists of six sequential components: an incoherent spectral band event detector that yields time and bearings of transient events; an interval estimator to remove weak airgun signals; a feature extractor that processes an input spectrogram to yield a 23-element feature vector; two feed-forward neural network classifiers that sequentially winnow out non-biologic signals and pinnipeds; a linking procedure to combine signals detected on sensors several kilometers apart; and a localization method that uses a maximum-likelihood procedure for estimating a position from a series of bearings. The software has been applied to data collected between 2007 and 2009 from at least 35 vector sensor autonomous recorders deployed over a 280 km swath in the Beaufort Sea. The largest dataset (2008) logged 1.35 million calls at 386,000 locations over 54 days across 40 recorders, and took 24 days to compute using a single 2.66 GHz processor. Comparison between manual and automated processing of the same datasets finds that both methods yield similar temporal and spatial call distributions, but the manual analysis is biased against weak calls, and the automated methods biased against calls accompanied by reverberation. [Work supported by Shell Exploration and Production Company].

Are Walrus Displacing Seals Along the Alaskan Chukchi Sea Coast?

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Large Pacific walrus beach haulouts were first observed along the Alaskan Chukchi coast in 2007 and then again in 2009 and 2010. These extensive beach haulouts have been observed along the Russian Chukchi coast but not along the Alaskan side and are believed to result from the lack of ice floes over their preferred shallow–water feeding grounds in the northern Chukchi Sea. The walruses arrived at beach haulouts in late Aug with the largest aggregations observed in September. Spotted seals frequent particular spits and shoals along Kasegaluk Lagoon during the summer and fall months. Spotted seal haulouts are in the vicinity of the walrus beach haulouts used in 2007, 2009 and 2010. In 2007, we saw one small spotted seal haulout in late July, but none after walruses moved into the area and there was a substantial decline in seal sightings in nearshore areas during September. During 2008, when no walrus haulouts were seen, spotted seals were seen at beach haulouts throughout August. Walrus occasionally eat seals and may be aggressive toward them. If walrus haulouts become more common due to declines in sea ice related to global warming, numbers of seals there may decline.

Gray Whale Distribution and Sightings Along the Alaskan Chukchi Sea Coast

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Gray whales migrate to the Alaskan arctic each year to feed. Distribution and movements of gray whales along the Alaskan Chukchi Sea coast were studied July through October 2006-08. In 2006 most sightings occurred in the central portion of the study area, whereas in 2007-08 most sightings occurred in the northern half of the study area with concentrations of animals in and around Peard Bay. The highest sighting rates were recorded within 5 km of shore in 2006 and at 25-30 km of shore in 2007-08. Gray whales were also observed benthic feeding, as evident from mud track sightings, farther offshore in both 2007 and 2008 than in 2006. Gray whale sighting rates were highest in 2007 with a peak monthly sighting rate of 12.36 sightings/1000 km in August followed by 2008 with 7.99 sightings/1000 km in July and 2006 with 2.77 sightings/1000 km in July. Differences seen in the distribution and sightings of gray whales may be linked to the varying ice cover. Ice cover in the greater Chukchi Sea was similar in 2006 and 2008, both of which had greater ice cover than 2007. However, in 2008 the nearshore survey area was predominately ice–free with isolated patches of ice pans from July to early–September. In contrast, during the 2006 pack ice and larger ice floes were always present within portions of our survey area from July to mid–September.

Preliminary Survey of Parasite Burden in Subsistence Harvested Ice Seals in Alaska

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Multiple internal and external parasites have been reported in Arctic seals. The frequency and severity of infestations varies among species of seals and geographic locations, reflecting differing modes of transmission. Pathogenic effects vary from no apparent damage to fatal airway obstruction, bowel perforation, poor body condition, decreased diving ability, or secondary pneumonia. Concern over possible changes in parasite exposure and pathology secondary to climate change have recently been reported and may include increased risk of human disease. A potential human pathogen (marine *Brucella*) has been linked to lung worms in harbor seals (*Phoca vitulina*) along the coast of Washington state and antibodies to *Brucella* have been found in ringed seals (*Pusa hispida*) and harp seals (*Pagophilus groenlandicus*) in Canada. Tissues from 55 subsistence-harvested seals (35 bearded seals (*Erignathus barbatus*), 15 ringed seals, 3 spotted seals (*Phoca largha*), and 2 ribbon seals (*Histriophoca fasciata*) were collected at five villages from 2006 to 2008 by the Alaska Department of Fish and Game. Grossly identifiable parasites were removed and submitted, along with fecal samples, to a veterinary parasitologist, who identified parasites and ova to genus, and species when possible. Results are reported by host and geographic location of harvest. Examination of samples collected from subsistence harvested ice seals over time will monitor shifts in parasite types and infestation levels in ice seals of Alaska.

BOWHEAD WHALES FEEDING IN ECHELON FORMATION

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Bowhead whales (*Balaena mysticetus*) migrate past Barrow, Alaska, during spring and fall. It is not uncommon for some of these whales to feed in the Western Beaufort Sea near Point Barrow in the summer, sometimes in large groups. On 12 September 2010, aerial observers in the Bowhead Feeding Ecology Study (BOWFEST) flew over a feeding group of more than 60 whales located 40 km east of Point Barrow in water approximately 5m deep. Many were in pairs or trios, and up to 5 whales were in echelon feeding position. Whales were on their sides (often right side) with mouths agape, one slightly behind the other, swimming in the same direction. Most whales in echelon formation were within touching distance, forming a pattern reminiscent of the V-formation of migrating geese. Echelon feeding may be beneficial because prey that escape the mouth of the lead animal are funneled into the mouths of subsequent animals who are also able to draft behind the lead whale thus reducing energetic costs of swimming. On 11 September 2010, boat-based sampling of hydrography and plankton was conducted in the same region. Winds from the east that cause upwelling followed by weak winds particularly from the south-southwest, can result in large quantities of krill being advected up and then “trapped” on the Beaufort Sea shelf. An observation of diel vertical migration in acoustic backscatter records in the area also indicates an abundance of krill, the likely causal mechanism of the high concentration of feeding whales.

Exploring America's Arctic from the Middle Atlantic Classroom

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Activities, including learning materials from the UMass Climate System Research Center Summer Institute introduce middle-grade and high school students to the study of the polar environment and uncertainties about human impacts on the climate system.

Special projects and presentations help these students from mid-latitudes appreciate the polar environment; people, flora and fauna of the North; and adaptations necessary to live there and deal with global change.

This project helps students appreciate the challenges ahead for the Arctic environment and its residents, and improves our understanding of climate variability over long and short timescales.

Subsistence Use and Knowledge of Beaufort Sea Salmon

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Pacific salmon species have increased in the Arctic Ocean during the last 10 years. Traditionally the communities along the Beaufort Sea have harvested pink and chum salmon, but increasingly Chinook and sockeye salmon are caught. This study documents and explores the use and knowledge of all Pacific salmon species in Beaufort Sea communities. We seek to understand local knowledge of the changes in salmon abundance, species composition, and related environmental factors in the region.

Semi-directed interviews have been conducted with 16 local subsistence fishers in Barrow. Expert fishermen and elders were identified by local leaders; snowball sampling was used thereafter. Interviews were audiotaped and transcribed. Qualitative data analysis with Atlasis currently underway. Geographic information was collected via participatory mapping methods about the location of salmon catches and other observations of change. Initial results suggest that salmon have not historically been an important subsistence resource; local fishermen have difficulty differentiating between species of salmon; some fishermen consider salmon to be a nuisance species clogging nets; fishermen are not aware of local salmon spawning locations; coastal erosion is affecting fishing practices; many fishermen and community members expressed concern about the possibility of the future development of a commercial fishery for salmon. Outreach activities in the community of Barrow have included a salmon identification lecture, radio interviews, and fishing derby development. We are currently extending this study to include the communities of Nuiqsut and Kaktovik.

Projected Changes in Timing and Extent of Sea Ice in the Bering and Chukchi Seas: Model Agreements and Model Uncertainties

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One consequence of global warming has been a rapid decline in Arctic sea ice over the past 3 decades—a decline that is projected to continue by state-of-the-art models. Here, projected changes in the Bering and Chukchi Seas are examined because sea ice influences the presence of, or accessibility to, a variety of resources of commercial and cultural value. In this study, 21st century sea ice conditions are based on projections by 18 general circulation models (GCMs) prepared for the IPCC Fourth Assessment Report (IPCC, AR4). A large spread of uncertainty among projections by all 18 models was constrained by creating model subsets that excluded GCMs that poorly simulated satellite observations of ice extent and seasonality. For the Chukchi Sea, projections show extensive ice melt during July and ice-free conditions during August, September, and October by the end of the century, with high agreement among models. High agreement also accompanies projections that the Chukchi Sea will be completely ice covered during February, March, and April at the end of the century. Large uncertainties, however, are associated with the timing and amount of partial ice cover during the intervening periods of melt and freeze. The ice-free season in the Bering Sea is projected to increase from its contemporary average of 5.5 months to a median of about 8.5 months by the end of the century, and the ice edge typically will pass through the Bering Strait in May and January rather than June and November as presently observed.

The spreading of a buoyant river plume beneath a landfast ice cover

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We use a set of simple numerical model experiments to examine how river plumes spread beneath the landfast ice cover over a continental shelf. The model is configured to resemble the seasonally frozen Colville River which flows onto the Alaskan Beaufort Shelf. We compare three cases: no ice, a landfast ice cover that extends 20 km and 60 km offshore. In the absence of ice a strongly stratified plume forms and transports river water eastward in a narrow (20 km wide) coastal current. For the 20 km wide ice cover, the stratified plume spreads offshore (and slowly eastward) until it crosses the ice edge. At the ice edge, the plume forms a narrow (~10 km) along-ice jet that flows swiftly eastward, seaward of the ice-edge. When ice covers the entire domain, the river influence extends across the width of the landfast ice domain and eastward flow is very weak everywhere. The difference among model runs is due to ice-ocean friction. When landfast ice is present, surface stress diverts the plume offshore in a frictional boundary layer. The plume continues to spread until the surface stress is relieved (at the ice edge). Although idealized, our results suggest that the spreading of buoyant plumes on arctic shelves differs markedly from those on ice-free shelves. The presence/absence of landfast ice will affect the fate of terrigenous sediments, and velocity and property distributions across the shelf. Hence lessons learned from mid-latitude buoyant plumes may not be transferable to landfast ice-covered shelves.

Interannual variability of the summer (June-October) temperature in the Chukchi Sea

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We present an analysis of the interannual variability for the summer (June-October) water temperature of the Chukchi Sea. The utilized array of the historical observation includes 28,536 CTD stations conducted in Chukchi Sea from 1920-present. Our analysis includes several steps.

First, we calculated the monthly climatological temperature fields for each month (June-October) in the Chukchi Sea. Second, we formed two arrays of the temperature anomaly with respect to the mean seasonal temperature distribution in the surface (0-20m) and subsurface (20-bottom) layers. Third, we calculated the temperature anomaly for the rectangular bins with dimensions of 2.0° (longitude) and 0.7° (latitude). Finally, we conducted the EOF analysis of the obtained surface and subsurface temperature anomalies in the Chukchi Sea. Analysis of the spatial and temporal variability of the obtained EOFs allows us to conclude:

1) The first EOFs in the surface (41.4%) and subsurface (32.1%) layers describe larger scale variability in the entire Chukchi Sea. Surface EOF has a maximum in the northwestern part of the Chukchi Sea, while subsurface EOF has a maximum in the central part of the Chukchi Sea.
2) The second EOFs in the surface (16.4%) and subsurface (13.6%) identify negative correlation between the temperature in the western and southwestern parts of the Chukchi Sea and temperature along the Alaskan coast and in the northern region of the Chukchi Sea.
3) There is an increase in temperature for the surface (1.6 – 2.3°C) and subsurface (0.7 – 1.0 °C) layers for the investigated period.
4) Analysis of the EOFs spectrums indentifies significant variability with periods of 2-4 years and 7-8 years in both layers.

Progress toward understanding lead patterns and landfast ice in the Chukchi Sea

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The Chukchi Sea has experienced dramatic reductions in sea ice extent in recent decades as the perennial sea ice cover of the Arctic as a whole has retreated. At the same time there has been growing commercial interest in offshore oil and gas development, with leases sold to approximately 1.1 million hectares on the outer continental self to 7 different companies in 2008. This has created the need to better understand the sea ice regime in this part of the Arctic in terms of its seasonality, lead patterns and the spatio-temporal distribution of landfast ice.

Here we present i) a qualitative analysis of lead patterns in the Chukchi Sea based on examination of Advanced Very High Resolution Radiometer (AVHRR) imagery and ii) preliminary measurements of landfast sea ice extent along the Chukchi coastline derived from synthetic aperture radar (SAR) data. We compare these with results from a previous study conducted primarily in the Beaufort Sea. Although landfast appears to undergo the same asymmetric annual cycle of gradual advance and rapid retreat, it is clear that the overall sea ice regime in the Chukchi Sea is quite different from that of the Beaufort. Identifying and categorizing lead patterns in the Chukchi Sea has proven more difficult than in the Beaufort since lead patterns do not last for long and changes spread rapidly across the whole region. Being farther south, the overall sea ice season is also considerably shorter.

Does the Alaska Coastal Current carry krill to the Arctic?

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Although the western Beaufort shelf near Barrow is recognized as a feeding 'hotspot' for bowhead whales during their westward fall migration, the pathway(s) by which their krill prey are carried by currents across the Bering and Chukchi Seas are not well known. One suggested pathway is associated with the relatively warm and fresh Alaska Coastal Current (ACC). Temperature, salinity, and acoustic backscatter data acquired by instruments moored on the southern flank of Barrow Canyon during late summer-early fall 2008 and 2009 indicate that krill (the presence of which is inferred from acoustically-detected occurrences of diel vertical migration) were more likely to be associated with waters that are colder and saltier than those characteristic of the ACC. Additionally, plankton tows conducted in the ACC in Barrow Canyon, including tows conducted at night, did not reliably collect krill. Together, these results strongly suggest that the ACC is not a significant advective pathway for krill to reach the Arctic.

Reanalysis of the Arctic Ocean and Chukchi Sea circulation and adjoint sensitivity analysis of the velocity observations

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In this presentation we discuss the results of the reanalysis of the annual mean Arctic Ocean circulations during the periods 1972-1978, 1989-1996, and 1997-2006. The reanalysis is derived from a variety of available observations by an efficient data assimilation system involving application of several data assimilation approaches. At the first stage of the reanalysis procedure we assimilate sea-ice data with a simplified nudging/optimal interpolation approach. Then, we apply a conventional strong constraint 4Dvar data assimilation technique and assimilate all available oceanic observations. The reanalysis involved the reconstruction of the multi-year mean Arctic Ocean circulation during the periods 1972-1978, 1989-1996, and 1997-2006. The obtained fields are used as a first guess for the reconstruction of the circulation for each particular year. Sensitivity of the reanalysis results with respect to the availability of the mooring velocity observations is evaluated by the adjoint sensitivity analysis. Additionally this analysis allows us to assess the efficiency of the velocity observation in the Arctic Ocean and High Frequency Radars in the southeast Chukchi Sea region. We show that adjoint sensitivity analysis can be applied for optimization of the observational system designed for monitoring large scale circulation in the Arctic Ocean and high resolution circulation in the Chukchi Sea and in particular in the southeast Chukchi Sea. The results of several OSSE experiments for the Chukchi Sea are discussed.

Role of Atlantic and Pacific Multi-Decadal Oscillations in Explaining of Russian Arctic Sea Ice Extent Dynamic During Twentieth Century

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The climate swings of the Atlantic Multidecadal Oscillation (AMO) are most evident in and around the North Atlantic and take roughly 60 years to complete. In the 20th century, the climate swings of the AMO have alternately camouflaged and exaggerated the greenhouse warming, and made attribution of global warming more difficult to ascertain. The data sets of the ice extents in the Russian marginal seas for 1900-1999 have been prepared in the Russian Arctic and Antarctic Research Institute. Our smoothing technique allows us to filter out the high frequency components presented in original time series and to reveal a 60-year AMO cycle in a more transparent mode. The AMO wavelet power spectrum demonstrates very strong anomaly area corresponding to a cycle of about 60 years, confirming the result based on the AMO series smoothing. Moreover, a statistical analysis showed the 60-year cycle to be a significant phenomenon at the 95% probability level. A smoothed ice extent curve for the Barents and Kara Sea September monthly data demonstrates slow multi-decadal oscillations similar to AMO, but opposite in phase. Wavelet analysis exhibits a power spectrum structure similar to those for AMO. The Pacific Decadal Oscillation (PDO) is detected as warm or cool surface waters in the Pacific Ocean. During a "warm", or "positive", phase, the west Pacific becomes cool and part of the eastern ocean warms; during a "cool" or "negative" phase, the opposite pattern occurs. It turned out that there is strong coherence between the PDO and ice extent in Chukcha Sea. Physical mechanism is based on wind impact of atmospheric circulation regime on ice extent in Pacific sector of Arctic generated by the SST anomalies in Northern Pacific. This relationship was confirmed by both techniques: smoothing and wavelet analysis.

A high-resolution view of carbon system parameters in the Canada Basin, Arctic Ocean

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Models project that the Arctic Ocean will become undersaturated with respect to carbonate minerals in the next decade. Recent field results indicate parts of the Arctic Ocean may already be undersaturated in late summer months when ice melt is at its greatest extent. Researchers from the U.S. Geological Survey (USGS) and University of South Florida (USF) collected high-resolution measurements of pCO_2, pH, total dissolved inorganic carbon (DIC), total alkalinity (TA), and carbonate ($[CO_3^{-2}]$) from the Canada Basin, up to 82°31'N, that fill critical information gaps concerning the variability of Arctic carbon flux. A Multiparameter Inorganic Carbon Analyzer (MICA) was used to collect over 22,000 measurements of air and sea pCO_2, pH, and DIC along a 9,450-km continuous track-line during August 2010. In addition, 240 discrete water samples taken approximately every two hours, and samples from eight stations with vertical Niskin casts down to 3,000 m were analyzed shipboard for $[CO_3^{-2}]$, pH, and TA. Samples were also collected to be analyzed onshore and include 240 samples for DIC and TA, and 220 samples for each of the following parameters: carbon and oxygen isotopes; dissolved organic carbon (DOC); and nutrients. These data are being used to characterize and model regional pCO_2, pH, air:sea CO_2 flux, and carbonate mineral saturation state. High- resolution maps of results will be presented.

Nitrogen fluxes and rates of microbial processes in the water column and sediment water interface of the Chukchi and Beaufort Seas

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Nitrogen dynamics were studied in the Chukchi and Beaufort Seas during the COMIDA cruise of 2010. Ammonium (NH_4^+) uptake and regeneration rates, and total sediment NH_4^+ demand, were measured concurrently with rates of denitrification, anaerobic ammonium oxidation, and dissimilatory nitrate reduction to ammonium. Fluxes of oxygen, nitrate (NO_3^-), nitrite (NO_2^-) and phosphate were measured at the sediment-water-interface. The regeneration and potential-uptake rates of NH_4^+ and nitrification rates were estimated by isotope dilution after additions of $15NH_4^+$ and $15NO_3^-$. Nitrogen dynamics at the sediment-water-interface were examined by changes in the composition of dissolved nitrogen ions and gases in water passed continuously over intact cores. The inflow waters of intact sediment cores were supplied with $15NH_4^+$ and $15NO_3^-$ to assess the rates of microbial processes. Mean fluxes of NO_3^-, NO_2^-, and PO_43^- were also assessed from cores. Sediment oxygen consumption ranged from around 150 to 400 umoles m^{-2} h^{-1}. We observed total N-gas effluxes up to 250 umoles m^{-2} h^{-1} in the Chukchi and influxes up to 3500 umoles m^{-2} h^{-1} in the Beaufort Sea. Sediments in Chukchi Sea were a source of NO_3^- while sediments in the Beaufort Sea were a sink of nitrate. Results elucidate the mechanisms of the N-cycle and quantify specific rates of key microbial processes, information fundamental to the development of models to describe and predict the effects of changes in N inputs into the region.

Shore-based, high-frequency surface current measuring radars in remote arctic settings

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High-frequency shore-based radars (HFR) collect hourly, realtime surface current data over broad areas of the coastal ocean and yield insights on the time-varying circulation, predict oil spill trajectories, evaluate circulation models, and in case of a spill, provide responders with realtime data on spill evolution. We show examples of HFR data collected recently on a 3 km grid extending from the central shelf of the Alaska Beaufort Sea and on a 6 km grid extending 170 km offshore over the Northeast Chukchi Sea continental shelf. In addition to showing results from these systems we will discuss HFR limitations with respect to sea ice, ionospheric interference, ambient weather conditions and siting constraints.

HFR requires 11kwH/day of AC power but the lack of power availability inhibits HFR use in Alaska. We developed a modular, autonomous remote power module (RPM) for arctic environments. The RPM design facilitates setup and transport to remote sites using small vehicles and it contains sub-systems for power generation, satellite communications, and monitoring power performance. The sub-systems are powered by a battery bank (with a 4-day power reserve) charged primarily by wind and solar and secondarily by a bio-diesel generator. The RPM is a stand-alone device for long-term deployments. It minimizes permit issues associated with diesel generators and logistics costs associated with refueling and maintenance. Performance data from a prototype RPM setup in Barrow Alaska in fall 2010 is provided. The system is designed for high-latitudes, but can be modified for remote coasts elsewhere.

Can we project Arctic summer ice minima from 2007 to 2010?

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The record low Arctic sea ice occurred in September 2007, followed by the second lowest in 2008, the third lowest in 2010, and the fourth lowest in 2009. Although the Dipole Anomaly (DA) has been identified as the major driver, what are the mechanisms for Arctic sea ice to gradually recover during 2008-2009, and to reduce again in 2010? This study examines these four cases in a great detail to search for dynamic and thermodynamic sound mechanisms, along with historical observations. It comes to the conclusion that under the thin-ice preconditioning (warming) during previous decade's positive Arctic Oscillation (AO) phase, local meridional wind anomaly associated DA during winter to summer is a major forcing for sea ice recovery. Intraseasonal variation of DA and its impact on sea ice advection will be discussed. Using the DA index to regress to previous summer ice minima, it is possible to project summer Arctic sea ice extent.

Future Status of the Chukchi Sea Seen from Global Climate Models

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Comprehensive Atmosphere-Ocean General Circulation Models (GCMs) are the major objective tools to account for the complex interaction of processes and feedbacks that determine future climate. While global climate models provide credible quantitative estimates of future climate at continental scales and above, the projections at regional scales from these climate models have larger spread and uncertainty. Yet climate projections at regional scales are in increased demand from governments, management agencies and other stakeholders. Our past studies showed that culling model based on their fidelity of simulated past climate to the observations can reduce the uncertain in the future projections. Here in this paper we present our approaches using two-step strategy to cull the models for Chukchi Sea. Decline of sea ice coverage is more prominent in the Chukchi Sea in the fall than in spring, which suggests a possible longer season of ice-free Chukchi sea in the future. The surface air temperature increase is strongest in winter.

R/V SIKULIAQ – A New Ice-capable Asset For The Future UNOLS Fleet

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The University of Alaska Fairbanks is constructing a new research vessel with a contract with Marinette Marine Corp. in Marinette, Wisconsin on behalf of the NSF for future scientific studies with an emphasis in the North Pacific Ocean and Alaskan waters. The 254-foot vessel will be capable of breaking 2.5 foot thick ice at 2 knots with an endurance of 45 days at sea and cruising at 14.2 knots. The vessel has formerly been known as the Alaska Region Research Vessel (ARRV) but has recently been named the R/V Sikuliaq (pronounced [see-KOO-lee-auk] which is an Inupiaq word meaning “new sea ice that is safe to walk on”).

The R/V Sikuliaq will have a beam of 52 feet and a draft of 18.9 feet that will carry 26 scientists and a crew of 20. Berthing accommodations are a combination of single/double rooms. One stateroom and the common areas of the vessel are designed for ADA access and accommodations. The total laboratory space (main, analytical, electronics, wet, upper, and Baltic room will be 2100 square feet. The 3690 square foot working deck that is approximately 70 feet in length will accommodate 2-4 vans. The vessel design strives to have the lowest possible environmental impact, including a low underwater-radiated noise signature. The science systems are prescribed to be state-of-the-art for bottom mapping, over-the-side “hands free” gear handling, broad band communications and scientific walk-in freezer and environmental chamber. The website address is www.sfos.uaf.edu/arrv.

Mesoscale Modeling Study on Chukchi/Beaufort Sea Wind Fields: Climatology, Variability, and Extreme Events

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Oil field development in the Chukchi/Beaufort seas requires an improved understanding of surface wind field, which is crucially important for driving ocean currents and dispersion of potential oil spills. In particular, extreme winds can occur in association with intense mesoscale weathers, causing a sudden change of wind, coastal flooding and erosion, wave surges, and infrastructure breakdowns. Thus, a project has been established to investigate the climatology and mesoscale structures of surface wind throughout the Chukchi/Beaufort seas and North Slope. In this project, we first extensively collected various reanalysis data and in-situ observational data from nearly 190 stations, including a 1.5-month buoy field campaign in the Beaufort Sea during summer 2009. We then conducted observational analysis and WRF model simulations. Examination of NARR data reveals an obvious seasonal cycle of wind speeds with a monthly minimum of 2.5–4 m/s in May and a maximum of 4–9 m/s in October. The frequency of wind speeds greater than the 31-year 95th percentile exhibits an obviously increasing trend, with the strongest increase in October and the weakest in May. We further analyzed the Arctic sea breeze, one of the major mesoscale phenomena, and found that during the snow-free season sea breeze circulations along the Beaufort Sea coast affect the surface wind fields in a different way compared to those usually seen at lower latitudes due to the specific environmental conditions of continuous solar irradiance, greater Coriolis effect, and local topographic forcing. Extreme winds are now occurring more frequently than before in a changing climate, with warming ocean and retreating sea ice cover. An intense mesoscale polar low was observed over the Beaufort Sea in October 2009, a rare occurrence in this area. By conducting a series of model simulations, we attempted to replicate this polar low and understand its formation and propagation. The polar low was found to form when a strong storm developed over the Bering Sea and warm air intruded into the Beaufort Sea area. The model results showed sensitivity to the initial and boundary conditions defined by different reanalysis data sets, with the smallest errors found when using ERA-Interim.

Polychaete Corral: an Experiment of Bioturbation Activities of a Polychaete

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Knowledge of benthic infaunal behavior has eluded many in the scientific community. Though more recent studies have been lacking, it is known that many burrowing species contribute to the important tasks of bioturbation and bioirrigation which aid in the movement of nutrients and dissolved oxygen in the sediment. An experiment to observe bioturbation activities of benthic infauna was designed using a home-made "ant-farm." Several polychaetes and bivalves were collected from the northeast Chukchi Sea using a van Veen grab. Collections were done in 2010 during the multi-year investigation funded by ConocoPhillips, Shell Exploration and Production Company, and Statoil. A single, large polychaete worm, *Nephtys paradoxa*, became the main focus of the study. Three trials were conducted in the field to find the optimum conditions in which to observe invertebrate behavior; the first employed the use of layered colored sand, the second was natural sediment, and the third was a combination of colored sand and natural sediment layers. Movements and interactions of the polychaete were successfully filmed and photographed. The *Nephtys paradoxa* burrowed deeper in the bottle filled with natural sediment compared to the experimental bottles (with layered colored sand) where the worm burrowed to approximately the same depth. The *Nephtys paradoxa* was observed taking granules of sand into its proboscis and forcing the granules out thereby causing the colored sand layers to mix. The purpose behind this behavior remains unknown.

Archiving the Project Documentation of the Census of Antarctic Marine Life

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The Census of Antarctic Marine Life (CAML) has been measuring the distribution and abundance of life in the Southern Ocean around Antarctica in order to assess potential changes in the marine environment. A major initiative of International Polar Year (IPY) and a key activity of Scientific Committee on Antarctic Research (SCAR), the results learned from CAML are critical for developing new paradigms for understanding and comparing marine biodiversity in polar areas. Traditional bibliographic databases already exist to track CAML results through formal publications, and institutional repositories and data centers are storing the metadata and related datasets. However, another type of 'metadata' exists—the miscellaneous documents produced during the development and ongoing activities of the CAML project itself. These publications often referred to as 'gray literature,' include internal reports, working documents, meeting minutes, pre-prints, and other materials not readily available because of lack of publication or a means of distribution. This poster outlines the steps taken to save CAML's non-traditional information, a unique and informative contribution of intensive planning and international cooperation efforts that would have likely been lost when the project ends. The success achieved through archiving the CAML project documentation in a freely available repository also serves a model for organizing the gray literature of future research projects, particularly when international or multi-institutional collaborative efforts are involved.

Influence of environmental gradients on infaunal community structure in the northeastern Chukchi Sea

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A multi-year, interdisciplinary study sponsored by ConocoPhillips and Shell Exploration and Production Company was initiated in the vicinity of two proposed oil and gas exploration areas in the northeastern Chukchi Sea. The investigation was designed to collect information on the ecosystem in these areas prior to exploration and provide environmental data useful for permit applications and for post-development comparisons. Sediment-dwelling macrofauna were collected for taxonomic analysis at 52 stations with a van Veen grab in August 2008 and 2009. The fauna found in 2008 and 2009 were abundant and biomass high although abundance, biomass, and the number of taxon found were all significantly higher in Burger compared to Klondike. A comparison to faunal assemblages of the northeast Chukchi Sea sampled in 1986 were comparable to those of 2008 and 2009 indicating little temporal change in the dominant species. Gradients in benthic community structure were associated with sediment size, physical variables, and distance offshore reflecting the geomorphology and hydrography in the study area. The advection of nutrient-rich water from the North Pacific Ocean and eastern Bering Sea contribute to the high abundance and biomass of faunal communities in the study area.

Sample Design for the 2010 – 2011 Chukchi Sea Alaska Monitoring and Assessment Program Survey

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The Alaska Department of Environmental Conservation and University of Alaska Institute of Marine Science jointly conduct the Alaska Monitoring and Assessment Program (AKMAP). Program focus is on applied environmental research using a sampling survey design to estimate the spatial extent of water quality status based on stressors, such as chemical contaminants, water quality parameters and indicators, such as benthic fish abundance. Sea bird and marine mammal transects and ocean acidification work is also part of the Chukchi Sea survey. The 2010 survey was conducted in the region from Pt Hope to Pt Lay, with work in Ledyard Bay, and 2011 will focus on the region from Pt Lay to Barrow, Alaska. The poster presents the survey sampling design methodology, parameters to be sampled, and discusses some preliminary information gathered in the 2010 survey.

THE CHUKCHI SEA ENVIRONMENTAL STUDIES PROGRAM: AN OVERVIEW

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In 2008, we began a multi-year, interdisciplinary ecological study (CSESP) in the vicinity of proposed exploration oil and gas prospects in the northeastern Chukchi Sea. This study, which was supported by ConocoPhillips, Shell Exploration and Production Company, and Statoil, was designed to collect information on the ecosystem prior to exploration to fill data gaps in this area and to provide baseline environmental data that can be used for permit applications and as baseline data for post-development comparisons. CSESP focuses on intensive studies conducted within two nearby study-area boxes (Klondike and Burger) that are 30x30 NM (~55x55 km) in size, ~40 NM (~70 km) apart, and located ~60–90 NM (~100–160 km) off of the coast of northwestern Alaska. The integrated studies consisted of the following components: physical oceanography; nutrients, primary productivity, and zooplankton ecology; benthic ecology; fisheries oceanography (2009 only); seabird ecology; marine-mammal ecology; hydroacoustics; and baseline chemistry (primarily 2008). We sampled the two study areas primarily during three research cruises that matched seasons within this arctic area: late summer, early fall, and late fall. We also deployed oceanographic and hydroacoustic moorings before and after these three cruises, during the open-water period, and deployed some over the winter. We describe the study background and study design to provide an overview for the various presentations on this study.

INFLUENCE OF WATER MASSES ON THE DISTRIBUTION AND ABUNDANCE OF SEABIRDS IN THE NORTHEASTERN CHUKCHI SEA

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We examined relationships between oceanography and the distribution and abundance of seabirds in the northeastern Chukchi Sea in 2008 and 2009 as part of a multi-year, interdisciplinary study supported by ConocoPhillips, Shell Exploration and Production Company, and Statoil. We had sufficient detections to generate density estimates for eight species after correcting for species-specific differences in detection probability. Procellariids were the most abundant species-group recorded during 2008, primarily because of large flocks of Short-tailed Shearwaters (*Puffinus tenuirostris*) that moved through both study areas in early fall. In contrast, alcids were the most abundant species-group recorded during 2009 and were primarily composed of Crested Auklets (*Aethia cristatella*). In both years, total density was highest in early fall, with densities in 2009 being at least 15 times higher than total densities in 2008. Diving alcids that forage on small zooplankton and nekton dominated in Klondike, whereas surface-feeding larids and procellariids that forage on large zooplankton and fish dominated in Burger. We propose that the structure of the seabird community differs substantially between the two study areas and that these differences reflect oceanographic differences between the two areas. The Klondike study area appears to be a pelagically-dominated system affected by oceanic water associated with the Central Channel Current, and the Burger study area appears to be a benthically-dominated system affected by remnant winter water associated with a gyre over Hannah Shoal.

COMIDA: Managing Marine Observations Data

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The Chukchi Sea Offshore Monitoring in Drilling Area (COMIDA) project is a robust, comprehensive effort to characterize the lease area biota and chemistry and to conduct a baseline assessment of the continental shelf ecosystem. Particular focus is on ship-based physical, chemical, and biological sampling of the benthos and on the development of a workable food web model.

As can be expected from such a multi-disciplinary effort, data management is an important and potentially challenging task and the COMIDA project includes a dedicated, ship-board data manager to provide real-time, field-based data services and Geographic Information System (GIS) support. Project data management is accomplished via the Observations Data Model relational database schema from a National Science Foundation-supported cyberinfrastructure project for the hydrologic sciences, used extensively for storing observations of the physical, chemical, and biological components of the water environment.

But actively managing data during the project isn't enough, as an interdisciplinary project of this magnitude and scope produces a wealth of information and represents a significant research investment. Effective project data management must include public outreach, data sharing, and data archiving both during and after the life of the project. As such, a secure, web-based system was developed for observational data storage (via the Integrated Rule-Oriented Data System (iRODS) grid software at the Texas Advanced Computing Center), geographic data storage (via the ArcGIS Online community), document sharing, and public outreach.

This presentation will include discussion of COMIDA back-end and front-end project data infrastructure as well as perspectives on data management and sharing.

USGS Study on Science Needs to Inform Decisions on Outer Continental Shelf Energy Development in the Chukchi and Beaufort Seas

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The U. S. Geological Survey (USGS) is conducting an initial evaluation of science needs to understand the resilience of Arctic coastal and marine ecosystems to Outer Continental Shelf resource extraction activities. The study will summarize what information is available, where knowledge gaps exist, and what research is needed to mitigate risks. The evaluation will look at the work done by many organizations that can help inform energy development decisions in the Arctic. The report will address issues such as 1) the effect of noise on marine mammals; 2) cumulative impacts of development, infrastructure, and maintenance activities offshore and onshore on ecosystems, landscapes, seascapes, water quality, seafloor and land stability, and subsistence hunting and fishing; 3) effective and reliable oil spill response in ice-covered regions; and 4) changing climate conditions and how they will either mitigate or compound the impacts from energy development in the Arctic environment. The analysis will focus on any particular concerns that may be unique to the Chukchi and Beaufort Seas. To accomplish this task in the timeframe allotted USGS has followed a structured process which includes identifying key vested organizations that have articulated science gaps on the topics, gathering previous assessments and workshop findings that reflect input from multiple stakeholders, and conducting a series of facilitated work sessions in Anchorage and Barrow.

Tectonics and Sedimentary History of the Arctic Ocean between Alaska and Canada

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For the past four years, researchers from the United States and Canada collaborated to study the tectonics and sedimentary history of the Arctic Ocean between Alaska and Canada, where ice cover has inhibited standard marine geophysical data acquisition of the seafloor and sub-seafloor. By modifying seismic equipment for ice and using two icebreakers in heavily ice-covered regions, both multichannel seismic reflection and coincident multibeam bathymetric data were acquired. More than ~12,000 trackline-km of high-quality vertical incidence seismic data and ~120 sonobuoy refraction records were acquired in the abyssal plain of the Canada Basin and on the surrounding slopes. The seafloor throughout Canada Basin is remarkably flat at ~3800 m, although isolated basement peaks rise above the seafloor near southern Alpha Ridge where deposition has not yet covered them. North-south transects show that the sedimentary package thins from maximum thicknesses along the Beaufort margin to pinching out and lapping onto basement on southern Alpha Ridge to the north and on Northwind Ridge to the west. The oldest stratigraphic sequences infill basement relief and are remarkably flat and variably, but generally weakly reflective. The middle stratigraphic sequences, while also flat, thin northwards, are generally more consistently reflective, and contain indications of mass transport deposits. The youngest stratigraphic sequences also thin northwards, but contain chaotic reflections, erosional surfaces, and geometries suggestive of extensive turbidite or mass wasting deposition. The Chukchi borderland and southern Alpha Ridge appear to be sediment starved, suggesting neither feature has been above sea level nor acted as a significant sediment source during the history of the basin. Remarkably little post-depositional deformation affected the sedimentary section, although one area between the Chukchi Borderland and southern Alpha Ridge shows a band of closely spaced normal faults that also affect some of the overlying depositional sequences. Basement is imaged throughout the basin with distinct reflection character. In most of the central Canada Basin, regions of low-relief, strongly reflective continuous basement surface are symmetrical about a zone of high-relief, poorly reflective basement blocks. This symmetry may be related to opening of the ocean basin. Further north towards Alpha Ridge, inferred basement contains deeper reflections and has relief suggestive of widely spaced volcanic edifices. Seismic data also image a large, buried graben in the deep water of northern Canada Basin off the Canada margin. These new observations suggest that the basin has been remarkably quiet tectonically since shortly after its formation.

Evidence for the Assimilation of Benthic Microalgae in Chukchi Sea Food Webs

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The rich benthic assemblages in the Chukchi Sea rely on phytoplankton, particulate organic matter advected through the Bering Strait, and ice algae as critical food sources. Our stable isotopic analyses confirm the dependence of benthic consumers on multiple carbon sources, with some organisms showing clear fidelity to specific sources. We found that the relatively heavy δ13C values (e.g. ~ -19‰) of some lower trophic level organisms may reflect dependence on benthic microalgae, a prevalent and more 13C-enriched carbon source. Microalgae isolated on the surfaces of the deposit feeding sand dollar *Echinarchnius parma* had an average δ13C of -19.35 (±0.32‰) Particulate organic carbon profiles show an enrichment of δ13C with depth that suggest a mixture of phytoplankton and resuspended microalgae compose a near-bottom composite of particulate matter that forms an important food source to benthic suspension feeders. δ13C values of POC ranged from near-surface values of -25.85‰ to near-bottom values of -20.84‰. The δ13C values of zooplankton (*Calanus* sp.; -21.64±0.41‰) also reflect the assimilation of this rich composite of benthic and pelagic microalgae. We believe benthic microalgae may be an overlooked but important and viable source of carbon for lower trophic organisms in the benthos. Porewater ammonium values varied from 111-348 μM in 2009 and 48-233 μM in 2010, and may provide an important source of nutrients to the microphytobenthos, which exhibit exhibit sediment chlorophyll values that range between 5.24 and 59.9 mg m^{-2}.

Development of a Distributed Biological Observatory (DBO) in the Pacific Arctic

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Although recent major changes in the physical domain of the Pacific Arctic Region (PAR) are well documented, such as extreme retreats and extents of sea ice, large uncertainties remain regarding responses in the biological domain. In the PAR, reduction in sea ice extent has been seasonally asymmetric, with minimal changes until late June and delayed sea ice formation in autumn. The effect of this seasonal asymmetry in sea ice loss on ocean primary production is equivocal, but there are clear changes in species distribution at higher trophic levels. To investigate ecosystem responses to extreme seasonal variability in sea ice, an initiative now underway is the development of a Distributed Biological Observatory (DBO) in the PAR. The DBO is envisioned as a change detection array for the identification and consistent sampling of biophysical responses to ocean climate variability at 'hotspot' locations across a latitudinal gradient. Four regions that exhibit high productivity and biodiversity are proposed for the DBO, the: (1) N Bering Sea; (2) Bering Strait/SE Chukchi Sea, (3) Central Chukchi Sea, and (4) Barrow Arc. The DBO will depend on international cooperation to sample oceanographic stations and conduct joint analysis of shared data. In 2010, a pilot DBO was conducted, focused on two of the four regions, with the resultant data to be made available though the nascent Sustaining Arctic Observing Network (SAON) process. Provisional results of this pilot effort will be presented, as well as suggestions for integration of community-science partnerships to future DBO sampling and analysis efforts.

Benthic invertebrate communities of the northeastern Chukchi Sea

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In 2008, a multi-year, interdisciplinary study was initiated in the vicinity of two proposed oil and gas exploration areas in the northeastern Chukchi Sea with a third area added in 2010. This study was sponsored by ConocoPhillips, Shell Exploration and Production Company, and Statoil to collect information on the ecosystem in these areas prior to exploration, and to provide baseline environmental data that can be used for permit applications and for post-development comparisons. Infauna was sampled using a double Van Veen grab in August 2008, 2009, and 2010 in the Klondike, Burger, and Statoil (2010 only) survey areas, while epifauna was sampled using a 3 m plumb-staff beam trawl with 4 mm codend liner in August and October 2009 and September 2010. Overall abundance and biomass was higher in the Burger area compared to Klondike. Infauna at Burger was comprised mainly of polychaetes and crustaceans (amphipods and ostracods). Klondike infauna was comprised of polychaetes and mollusks. Epifauna at Burger was comprised of brittle stars and sea cucumbers, and Klondike was dominated by brittle stars and shrimp. Preliminary observations of epifauna at the Statoil survey area indicate that it was dominated by brittle stars and shrimp similar to that of Klondike; although sea cucumbers were also numerically dominant similar to Burger. The macrofaunal communities (both infauna and epifauna) reflect environmental gradients in the northeast Chukchi Sea. Burger seems to be a depositional zone for finer sediments which was indicated by the macrofaunal communities and the higher occurrences of benthic omnivores there.

Fish Community Observations for Three Locations in the Northeastern Chukchi Sea

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Demersal and pelagic fish sampling was conducted during September 2010 in the northeastern Chukchi Sea. This information, supported by ConocoPhillips, Shell Exploration and Production, and Statoil will add to the current datasets for fish communities in the region. A total of 37 stations were sampled in three neighboring 3100 km^2 study areas (Klondike, Burger, and Statoil). Statoil was the most northerly study area and was adjoined to the Burger study area to the southwest. Klondike was centered 70 km southeast of Burger. An additional six transitional stations, located between Klondike and Burger/Statoil, were sampled. Demersal fish were sampled primarily with 3-m beam and plumb staff beam trawls. The pelagic water column was sampled with an Isaacs-Kidd midwater trawl and a 10 x 10-m midwater trawl. Pelagic fish were primarily planktonic and made up 3% of the total catch. Within individual study areas the demersal species richness ranged from 16 (Burger) to 17 (Statoil) to a high of 20 (Klondike), for a total of 23 species. Arctic cod (*Boreogadus saida*) were 42% of all catches and were present at all sites. Other common fish included hamecon (*Artediellus scaber*, 9%), stout eelblenny (*Anisarchus medius*, 9%), and Arctic staghorn sculpin (*Gymnocanthus tricuspis*, 6%). Klondike had the highest fish density (22,098 fish/km^2) while the densities of Statoil and Burger were much lower (5,577 fish/km^2 and 5,160 fish/km^2 respectively). In addition, three fourhorn poachers (*Hypsagonus quadricornis*) were captured approximately 600 kilometers north of Bering Strait, well outside their documented range in the Bering Sea.

Inter-annual Variability of the Planktonic Communities in the Northeastern Chukchi Sea

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The planktonic communities of the Northeastern Chukchi Sea were examined as part of a multi-year, interdisciplinary study supported by ConocoPhillips, Shell Exploration and Production Company and Statoil. We sampled two neighboring 30 x 30 NM grids (Klondike and Burger) at high spatial resolution three times per ice-free season in 2008 and 2009, with a third grid added in 2010. Chlorophyll a, macronutrients and zooplankton (150µm and 505µm mesh nets) were collected at 25 stations within each grid. In 2009, the ice retreat and spring bloom were earlier, concurrent with warmer sea surface temperatures over the region than observed in 2008 or 2010. Multivariate analysis demonstrated temporal evolution of the zooplankton community in each year, but with clear differences between years. Interestingly, although seasonally-averaged abundances and biomass were relatively similar between years, differences in the timing and magnitude of key species was of consequence to higher trophic levels. In total, 76 taxonomic categories of holoplanktonic zooplankton were observed, with the greatest taxonomic diversity observed in the copepods (20 species), followed by cnidarians, with significant contributions by meroplankton to both abundance and biomass. In general, the species dominating this region during the ice-free season are largely of Pacific origin, consistent with observations spanning nearly 80 years.

Metagenomics as a tool for assessing microbial diversity in areas affected by oil drilling

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Plans to responsibly drill for oil in the Arctic region have brought to light the need for tools to assess the impacts of drilling activities upon the biodiversity of the region. Though often overlooked in these assessments due to a lack of adequate technologies, no component of the Arctic biosphere is more diverse, or possibly more relevant, than the microbiota. In recent years, the technologies of metagenomics, wherein microbial nucleic acids can be extracted from an environmental sample and sequenced almost in their entirety, have become widely available. Nucleic acid signatures for both culturable and unculturable organisms are captured, and when computationally processed they yield a microbial community “profile” that is both taxonomically and functionally descriptive. In 2007 metagenome data sets were published from the Sorcerer II Global Ocean Sampling (GOS) expedition spearheaded by the J. Craig Venter Institute. The GOS expedition sampled the marine planktonic microbiota from the North Atlantic through the South Pacific, and conveniently covered areas of similar conditions and latitudes but which had different disturbances with respect to oil drilling. Here we demonstrate that such data has the potential to yield:

1) Measurements of baseline microbial biodiversity that can be used as a valuable index for assessing environmental impacts,
2) The discovery of novel microbes that may be involved in the degradation of light, crude oil into denser heavy oils, and
3) The discovery of novel microbes that could contribute to the bioremediation of spilled oil.

Historical studies of macrofauna of the northeastern Chukchi Sea

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Sediment-dwelling macrofauna of the Chukchi Sea were sampled by investigators from the Institute of Marine Science throughout the 1970's and 1980's. An extensive collection of data encompassing infauna and epibenthic macroinvertebrate fauna is now publically available from these investigations. Comparisons of data from the multi-year, interdisciplinary study sponsored by ConocoPhillips and Shell Exploration and Production Company from 2008 to 2009 to historical data for the northeast Chukchi Sea demonstrate that faunal assemblages were similar between time periods. Trends in the faunal data indicate responses to environmental gradients (e.g., geomorphology and current patterns covarying with depth, sediment grain-size, and bottom water temperature and salinity) and physical dynamics reflected in coastal to offshore gradients. The smaller-scale 2008 and 2009 study demonstrates faunal changes associated with geomorphology hidden in the large-scale sampling of the historical studies.

Developing a trophic mass balance model of the eastern Chukchi Sea

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A growing body of research has expanded our knowledge of species distribution, biomass, abundance, and trophic interactions within the Chukchi Sea. To date there has been no synthesis of this information into a modeling framework using common ecological currencies. Here, we present the initial steps to integrate existing data into a mass-balance food web model of the eastern Chukchi Sea. The model describes the trophic structure and functioning of the marine community inhabiting the continental shelf at depths of less than 70m and within the US EEZ between Bering Strait and Pt. Barrow. The total model area encompasses approximately 205,000 square km. We aggregated species information into functional groups when information was sparse, but otherwise sought to represent species individually. Here we document model construction including the input data, diet data, and functional groups. Also presented are the preliminary model parameters including biomass, production, consumption, and ecotrophic efficiency for all functional groups. This preliminary model provides an annual snapshot of ecosystem organization and illustrates the magnitude of flows between functional groups. This model can be used to support and ecosystem-based approach to making management decisions.

SEARCH: Study of Environmental Arctic Change—A System-scale, Cross-disciplinary Arctic Research Program

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The Study of Environmental Arctic Change (SEARCH) is a multi-agency effort to understand system-scale arctic change. Interrelated environmental changes in the Arctic are affecting ecosystems and living resources and are impacting local and global communities. The SEARCH program is guided by the Science Steering Committee (SSC), the Interagency Program Management Committee (IPMC), and focused panels. Over 150 projects and activities contribute to SEARCH implementation.

The Observing Change component is underway through the National Science Foundation's (NSF) Arctic Observing Network (AON), NOAA-sponsored atmospheric and sea ice observations, and other relevant national and international efforts.

The Understanding Change component of SEARCH consists of modeling and analysis efforts, with strong linkages to relevant programs such as NSF's Arctic System Science (ARCSS) Program. The SEARCH Sea Ice Outlook (http://www.arcus.org/search/seaiceoutlook/index.php) is an "Understanding Change" synthesis effort that aims to advance our understanding of the arctic sea ice system.

The Responding to Change element currently includes initial planning efforts by the International Study of Arctic Change (ISAC) program as well as a newly-launched "Sea Ice for Walrus Outlook," which is a weekly report of sea ice conditions geared to Alaska Native walrus subsistence hunters, coastal communities, and others interested in sea ice and walrus (http://www.arcus.org/search/siwo).

SEARCH is sponsored by eight U.S. agencies, including: the National Science Foundation (NSF), the National Oceanic and Atmospheric Administration (NOAA), the National Aeronautics and Space Administration (NASA), the Department of Defense (DOD), the Department of Energy (DOE), the Department of the Interior (DOI), the Smithsonian Institution, and the U.S. Department of Agriculture (USDA). The U.S. Arctic Research Commission participates as an IPMC observer.

For further information, please visit the website: http://www.arcus.org/search or contact: Helen V. Wiggins: helen@arcus.org, SEARCH Project Office, Arctic Research Consortium of the U.S. (ARCUS); or Hajo Eicken, hajo.eicken@gi.alaska.edu, SEARCH SSC Chair.

Large-scale modeling of primary production and ice algal biomass within arctic sea ice

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Algae growing within sea ice may form a significant portion of the primary production in ice-covered seas. Because of the challenges in accessing and making measurements in remote ice environments, observations of ice algae are sparse. Modeling studies can help fill in the data gaps and can be particularly informative for the time period preceding and during ice breakup. In this modeling study, an ice ecosystem model was coupled to a global dynamic sea ice model to assess large-scale variability of primary production and ice algal biomass within arctic sea ice. The component models are the ice ecosystem model developed at the International Arctic Research Center and the Los Alamos National Laboratory sea ice model, CICE. Simulated annual arctic sea ice primary production was 15.1 Tg C; within the range of 9 to 73 Tg C estimated using in situ data. The amount of C fixed was > 3 Tg C $mnth^{-1}$ for March, April, and May. The Bering Sea, Arctic Ocean basins, and the Canadian Archipelago/Baffin Bay were the most productive regions on an annual basis, contributing approximately 24%, 18%, and another 18%, respectively. High production in the Bering Sea was due to high daily production rates, while the large sea ice area in the Canadian Archipelago/Baffin Bay and, in particular, the Arctic Ocean basins resulted in their considerable contribution to sea ice primary production. The simulated trends, patterns, and seasonality of ice algae agree reasonably well with very limited observations. The model described advances the role of sea ice algae in biogeochemical cycling within global climate models.

Organic Contaminant Distributions and Transfer in Shelf Sediments and Biota of the Chukchi Sea: Results from the COMIDA Program

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In 2008, Chukchi Sea Offshore Monitoring in Drilling Area (COMIDA) program, supported by the Mineral Management Service (now BOEMRE) began a comprehensive assessment of the Chukchi Sea Lease Sale 126 area. The major goal is to provide baseline data on chemical concentrations and benthos. Efforts to characterize the biota, water column properties and sediment chemical composition began in the summer of 2009 and continued with additional sampling in the summer of 2010. Although essential to identify impacts from oil and gas development and production, a broader goal of the program is to provide a comprehensive study of the Chukchi shelf to characterize carbon sources, cycling and trophic linkages through a variety of measures. As part of the chemical assessment, surface sediments representing 30 sites spanning the study area have been analysed for aliphatic hydrocarbons and anthropogenic markers (Polycyclic Aromatic Hydrocarbons – PAH's) to examine distributional trends and concentrations as well capture the northern and southern boundaries of the Chukchi sea. Concentrations of anthropogenic organic contaminants were vary over 4 fold across the across the study sites but are generally low with summed PAH concentration of <1 ug/gm sediment. A more varied alkane hydrocarbon distribution was seen with major contributions derived from natural sources. Additional chemical analyses being conducted include the use of lipids as organic carbon markers of trophic transfer to complement contaminant analysis as well as baseline toxicological measures of fish species. Analysis of lipid biomarkers in major benthic species included the northern Neptune whelks (*Neptunea heros*) to examine the potential for trophic transfer and ecological linkages. Baseline toxicological studies of the Arctic cod collected in 2010 includes both genetic and enzymatic measures to provide important baseline responses of resident species in this region. Taken together, the COMIDA program will provide an important addition to understanding the chemical and ecological status of the Chukchi Sea.

Reconstructing the ocean's past: Rescue of 1970s zooplankton data from the Beaufort Sea WEBSEC cruises

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A major challenge in climate-related studies is lack of historical data against which to assess biological response to changes in the physical environment. We report here 2 "lost" cruises by the Western Beaufort Sea Ecological Cruises (WEBSEC) program in the early 1970s. More than 100 zooplankton stations from 11 cross-shelf transects taken during the Coast Guard's WEBSEC-72 were never processed, but sat quietly in NOAA's warehouses. They have now been processed using modern taxonomic standards, with attention to the typically overlooked rare species. Collections from WEBSEC-71 that covered the same region were processed as part of a master's thesis, but they were never published in the main-stream literature and the information effectively "lost". Although there are some similarities between these cruises, WEBSEC-72 collections record at least twice as many species as WEBSEC-71 due to differences in taxonomic detail. This data, along with that from the Outer Continental Shelf Environmental Assessment Program (OCSEAP) during 1976-78 help lay the foundation against which any major changes in the zooplankton communities of the Beaufort Sea could soon be assessed.

Food web structure and epibenthic megafauna in the Chukchi Sea – a temporal comparison

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The Russian-American-Long-term-Census-of-the-Arctic (RUSALCA) aims at building a time series of data on environmental and biotic conditions in the Arctic Chukchi Sea shelf ecosystem, an area experiencing substantial climate change. Here we present a first comparison of food web structure and of epibenthic abundance and biomass from 2004 and 2009. Regional food web structure based on carbon stable isotope ratios in 2004 differed, with benthic organisms in the eastern (Alaska Coastal Water, ACW) Chukchi Sea feeding more on terrestrial materials than in the western part (Anadyr Water, AW). Similar patterns were found in 2009, but a δ13C depleted food source in the AW indicates freshwater influence in that region in 2009. No changes in trophic position based on δ15N ratios were found between the two time periods, indicating stable food webs, which may make them particularly good indicators for long-term changes. Quantitative data on the epibenthic megafauna were taken from a total of 60 beam trawl samples taken in 2004 and 2007-2009, including 8 resampling stations. Gross abundance and biomass estimates ranged from 229-70,879 ind. 1000 m^{-2}, and from 1628-217,023 g wet wt 1000 m^{-2}, respectively. Abundance and biomass were dominated by echinoderms (66 and 45%, respectively) and crustaceans (17 and 31%, respectively). Of the total 165 taxa identified, 45 were mollusks and 33 were crustaceans. Comparisons between 2009 and 2004 and with previous studies suggest an increase in overall epibenthic biomass (since 1976), including an increase in the biomass of one of dominant species, snow crab (*Chionoecetes opilio*).

Modeling study of primary production in the pan-Arctic regions

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In the Arctic Ocean, both phytoplankton and sea ice algae are important contributors to the primary production and the arctic food web. A global coupled ice-ocean-ecosystem model was established to investigate ice-ocean biogeochemical cycle and the ice-ocean ecosystem modules are fully coupled in the physical model POP-CICE (Parallel Ocean Program- Los Alamos Sea Ice Model). The model results are compared with various observations and the focus here are on the perspectives of the ice and ocean primary production in the Arctic Regions. The modeled sea ice algal carbon production shows reasonable seasonal successions of blooms from the subarctic toward the central Arctic and is in the comparable ranges of observations in the Chukchi Sea and the total amount in the pan-Arctic Regions. The phytoplankton blooms in the ocean starts with ice-edge blooms in the marginal ice zone, especially on shelf regions where nutrients concentrations are high. The ocean primary production is one order higher than the ice algal production in the subarctic seas and the shelf regions of the Arctic, while both are low in the central arctic due to nutrient limitation. The model reproduced the spatial distribution of the annual carbon production levels in the upper 100m of the Arctic Ocean. The contributions to primary production by the large and small size of phytoplankton are discussed while comparing with the limited observations made by various Arctic expeditions.

S**ummer 2010 Hydrography and Zooplankton on the Chukchi Sea Shelf (the CHAOZ Project)**

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The EEZ of the U.S. Arctic is vulnerable to both natural and anthropogenic changes. Climate warming is predicted to be accentuated at the poles, and recent rates of summer sea ice loss exceed the current model estimates. Exploration and drilling for oil and gas may present another type of change or disturbance to this shelf ecosystem. In the summer of 2010 we began a biophysical examination of the structure and function of the shelf ecosystem concentrating on hydrography, zooplankton and whale distributions. We occupied over 50 stations on 5 cross-shelf transects from Point Hope to Wainwright, Alaska. CTD and water bottles were used to collect hydrographic information, and a 1 m-squared Tucker Sled equipped with a 6-frequency Tracor Acoustic Profiling System (TAPS-6) were used to collect information on zooplankton. During our time in the area the column was strongly stratified in most locations, and there was a conspicuous lack of large zooplankton scatterers such as euphausiids. Intrusion of northern Bering Sea shelf water was evident in the hydrography and by the presence of the large scyphomedusae jellyfish, *Chrysaora melanaster*. Biophysical moorings were deployed at three locations along the Icy Cape transect line to make frequent (every 20 – 30 minute) measurements on currents, hydrography, light, nutrients, ice thickness, and zooplankton biomass and size composition. The instruments will remain at these locations for an entire year, hopefully providing a rich suite of under ice measurements as well as the seasonal cycle of physical forcing in this under studied ecosystem.

Temporal variability of epibenthic trawl surveys in the Chukchi Sea

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The rich Arctic epifaunal community constitutes a large part of the benthic biomass. Furthermore, they contribute to the benthic energy turnover, and are important in many trophic interactions and bioturbation activities. Many environmental variables affect the abundance and distribution of epibenthic species in the Arctic, including sea ice cover, substrate characteristics, depth, salinity, and food availability. The objective of this study was to analyze the temporal variation in epibenthic organism distribution and abundance in the Chukchi Sea. As a part of the COMIDA (The Chukchi Sea Offshore Monitoring in Drilling Area) study, 10 stations were trawled for epibenthic fauna in 2009 and 2010. Important inter-annual variability was observed at many of the stations with a number of groups describing this variability, including *Chionoecetes* and *Hyas*, which showed a total increase in biomass in 2010. The abundance and distribution of *Colus*, *Echinarachnius* and *Ocnus* were particularly variable between years, with an increase in abundance in 2010. The interest in potential economic activities in the Chukchi Sea has created an intrinsic need for a better understanding of the fluctuations in abundance and distribution of these epibenthic organisms.

Assembling pan-arctic patterns of zooplankton abundance

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We assembled zooplankton data from a wide variety of sources, and designed a predictive ecological niche model for the Arctic Ocean using ArcGIS. The model was employed to map the summer-time distribution and abundance of the three dominant arctic endemic copepod species (*Calanus hyperboreus*, *C. glacialis*, and *Metridia longa*) plus a Pacific species (*M. pacifica*) and an Atlantic species (*C. finmarchicus*) that are seasonally expatriated into the Arctic. We pooled data regardless of year, then overlaid observed abundances with climatological environmental data (e.g. salinity, water temperature, bathymetry, ice cover, etc.) to predict species-specific abundances throughout the Arctic Ocean. In some regions with rich data sets, predictive performance by the model was high, whereas in regions with sparse data, predictive skills were low. Patterns related to distance from advective gateways, water depth and distance from the continental shelf are presented. Future efforts will continue the process of data consolidation such that decadal patterns in zooplankton abundance can be explored, as well as examining future climate change scenarios.

COMIDA: Trophic Patterns of Organic Contaminants and Lipids in the Chukchi Shelf Benthos

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The Chukchi Sea Offshore Monitoring in Drilling Area (COMIDA) program integrates both biological and chemical disciplines to provide a comprehensive baseline assessment of the Chukchi shelf and benthos prior to potential oil and gas development. Efforts to characterize the biota, water column properties, and sediment chemical composition began in the summer of 2009 and have continued through the summer of 2010. An important goal is to expand beyond simple concentration information to examine trophic links for organic contaminants and we determined concentrations of important organic contaminants (PAHs and aliphatic hydrocarbons) as well as lipid biomarkers in the foot muscle of northern Neptune whelks (*Neptunea heros*). Multiple size ranges were examined as well as concentrations of natural and anthropogenic lipids in their primary prey, the northern clam *Astarte borealis*, and surface sediment collected from the same site to compare trends and concentrations. While a diversity of PAHs and aliphatic hydrocarbons are seen among all sample types, concentrations appear higher in surface sediment compared to both *N. heros* and *A. borealis*. It also appears that *N. heros* excrete or metabolize contaminants; initial analysis suggests that concentrations also do not increase with body size. Using lipid biomarkers in *N. heros*, *A. borealis*, and surface sediment, we were also able to investigate trophic patterns and potential carbon sources and cycling on the Chukchi shelf. Surface sediment was dominated by marine derived organic carbon sources and a broad diversity of lipid signatures was also present in both animals' tissues. Surprisingly, algal specific lipid markers were present in substantial concentrations in *N. heros*, suggesting the incorporation of primary production either directly through detrital feeding or via trophic transfer through their prey.

Migratory movements and wintering sites of Red-throated and Yellow-billed loons from the Arctic Coastal Plain, Alaska

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Red-throated (*Gavia stellata*) and Yellow-billed (*G. adamsii*) loons are waterbirds of conservation concern due to unexplained population decline and small population size, respectively. These species nest on tundra habitats in Alaska and reside on coastal marine waters when not occupying inland nesting lakes. Despite their reliance on the marine environment, little is known regarding loon use of coastal habitat in Alaska, migration routes, or wintering sites. To describe loon distribution in the marine environment, we deployed satellite transmitters (PTTs) on Red-throated and Yellow-billed loons captured on the Arctic Coastal Plain of Alaska. Locations from PTTs indicated that most loons departed inland lakes late-August through September. Loons migrated through the Chukchi Sea to wintering areas primarily located in Asia. During spring migration, loons were first detected offshore from the Arctic coast of Alaska during early- to mid-June and moved to inland lakes shortly after arrival. Red-throated Loons used marine habitat for foraging throughout the summer. During migration, loons were located nearshore at average distances of 6.61 km (range 0.06-56.69 km) and 20.3 km (range 0.04-144.0 km) from the coast for Red-throated and Yellow-billed loons respectively. These preliminary results indicate that nesting adult loons reside nearshore on the Chukchi and Beaufort sea coasts primarily during the months of June, August, and September; however, some Yellow-billed Loons were located on coastal waters throughout the summer. Locations of PTT-tagged loons indicate strong connectivity between nesting grounds on the Arctic Coastal Plain and wintering sites in Asia.

Distribution and migratory timing of threatened Spectacled Eiders in the Beaufort and eastern Chukchi seas

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Nearshore areas of the Beaufort and eastern Chukchi seas are important staging and molting sites for waterfowl that breed in Arctic Siberia, Alaska, and Canada. Spectacled Eiders, sea ducks listed as 'Threatened' under the U.S. Endangered Species Act, occur in the Beaufort and eastern Chukchi seas annually. However, little is known about the distribution of eiders in these areas. To learn more about the distribution and migratory timing of Spectacled Eiders, we implanted satellite transmitters in juvenile (2010, n = 13) and adult (2009, n = 21; 2010, n = 16) eiders at nesting areas in northern Alaska. Early results from our ongoing study showed that eiders used the eastern Chukchi Sea to migrate, stage and molt between the months of May and October, and the Beaufort Sea to migrate and stage between June and September. A majority (76.5%, 26 of 34) of adults breeding in northern Alaska molted from August through September near Kasegaluk Lagoon, Alaska in the eastern Chukchi Sea. 8 out of 9 adults returning to northern Alaska breeding areas in spring 2010 staged in the eastern Chukchi and/or Beaufort Sea during migration. In both seas, the density of eiders was greatest (50% fixed kernel) within 30 km of the coast of Alaska. Some eiders used areas up to 100 km off the eastern Chukchi Sea coast during spring (n = 1) and fall (n = 3) migration. Our results support the importance of nearshore areas of the eastern Chukchi and Beaufort seas for Spectacled Eiders breeding in northern Alaska, and contribute to ongoing planning for industrial development in these areas.

First Records of the Genus *Lepidion* (Gadiformes, Moridae) from Alaska

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During recent analysis of deep-sea video taken from an ROV off the central Aleutian Islands in 2004, we observed two deep-sea codlings (family Moridae) that appear to be *Lepidion* sp., a genus not documented from Alaska. Three Morid species representing three different genera have been previously documented in Alaska: the Pacific flatnose (*Antimora microlepis*), the longfin codling (*Laemonema longipes*), and the slender codling (*Halargyreus johnsonii*). The presence of other Morids was thought probable since two species representing yet a fourth genus (*Lepidion*) had been documented as close as the Commander Islands off Russia (*L. schmidti*) and the Emperor Seamounts south of the Aleutian Archipelago (*L. schmidti* and *L. inosimae*). We analyzed video footage along more than 39 km of seafloor from 13 dive locations ranging from 170 to 2,947 m deep. Both fish were observed at a single site, southeast of Adak Island, within a meter of the sea floor; one was at a depth of 1714 m and the other at 1676 m. Both were estimated to be >65 cm total length, had an elongate filament on the first dorsal fin, a long chin barbel, protruding upper jaw, anal fin origin near body midpoint, and anal fin only slightly indented. The images of the two *Lepidion* off southeast Adak Island represent an eastward range extension for that genus of approximately 1,350 km, and the first documentation of *Lepidion* in Alaska. The poster presents still photos snapped from the video and details of both sightings.

Variation in growth of juvenile salmon in the Eastern Bering Sea: insights produced by measuring the hormone insulin-like growth factor 1

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The hormone insulin-like growth factor 1 (IGF1) is a primary mediator of growth in all vertebrates. Recent laboratory work has demonstrated that plasma levels of IGF1 correlate well with growth rates over periods of 1 to 2 weeks ($r = 0.6$ to 0.9) in juvenile salmonids. This result suggests that IGF1 may serve as a growth index for juvenile salmon in marine environments. Work conducted in the Northern California Current off the Oregon/Washington Coast over the past decade has demonstrated a) plasma levels of IGF1 of juvenile coho salmon in June vary significantly between years, b) variations in plasma IGF1 are well correlated to variation in large zooplankton (salmon food) and c) plasma IGF1 levels can serve as a recruitment index for coho salmon as IGF1 level in juvenile coho salmon are well correlated to adult survival.

In 2009 and 2010 plasma samples were collected from juvenile salmon captured in on-going surveys of both the Northeast and Southeast Bering Sea during the late summer and autumn, including sockeye, Chinook, pink and chum salmon. Spatial and temporal variation in IGF1 levels among and between species was present. Variations in juvenile salmon growth will be interpreted with regard to regional and inter-annual variation in oceanographic processes. In addition, the potential for IGF1 levels to serve as a recruitment index for Bering Sea salmon will be discussed.

Enhancing benthic habitat surveys by combining scanning sonar imagery with video from towed ROVs

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AquaLife Engineering has provided ROV charters in Alaskan waters since 1999 for a variety of marine biological, fisheries, and oceanographic projects. Some of these projects have involved searching for and surveying both bairdi and king crab, and we have utilized scanning sonar to increase our effectiveness.

In general, a visual survey using a towed ROV or sled provides a swath width of 1 to perhaps 3 meters. This range can be extended to as much as 100 meters using scanning sonar. Depending on the bottom type, we have been to reliably detect individual adult red king crab at a range of 50 meters using a 325 kHz sonar head.

An ROV towed on a bridle behind a downweight can be deviated laterally to provide video images of targets previously detected by the sonar at long range. By using this approach, the identity of various organisms can be correlated to the sonar signature of those targets once they are tracked into video range, allowing abundance correlations to be developed for the entire 100 meter sonar swath width.

Video and sonar images are presented and compared for king crab, *bairdi* crab, starfish aggregations, and schools of juvenile tomcod.

Three keys to increasing the cost effectiveness of habitat surveys are: 1) Increase swath width; 2) go faster; and 3) don't lose your gear. Scanning sonar imagery from a towed ROV can contribute to increasing swath width, seeing further ahead so that you can go faster with less risk, and detecting obstructions early enough that they may be avoided.

New Management Challenge in Alaska – Octopus!

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Recent changes to the federal Fishery Management Plans for the Bering Sea and Aleutian Island and Gulf of Alaska remove all species groups from the 'other species' category to the 'target species' category. Beginning in 2011, sculpins, sharks, skates, squid, and octopus will all be managed separately, with each group having its own annual catch limits (TAC, OFL). These regulation changes have presented new challenges and spurred new research for stock assessment scientists.

One of the most problematic groups is octopus. There are at least eight species of octopus in Alaskan waters, but very little is known about the abundance, distribution, or biology of these animals. Basic life-history parameters such as age at maturity, fecundity, and reproductive season are undocumented in Alaskan waters, even for the best-known species. Octopus are caught in both state and federally-managed fisheries, and may undergo a seasonal migration between state and federal waters. Estimating the existing biomass of octopus is problematic. The bottom trawl survey that provides biomass estimates for groundfish catches only a few octopus, primarily very small individuals. The majority of the commercial catch, in contrast, comes from Pacific cod pots which retain only very large animals. Octopus are terminal spawners and have a maximum age <5 years, making it difficult to use models to estimate natural growth or mortality rates. Catch limits on incidental species such as octopus can have substantial implications for target fisheries; the challenge is to find ways to manage octopus while avoiding unnecessary constraint of cod fisheries.

Condition of Bering Sea Chinook Salmon Entering Winter

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Most salmon species leave the Bering Sea in winter, migrating southward to the North Pacific Ocean. Western Alaska Chinook salmon are an exception, and some northern populations spend their entire ocean life in the Bering Sea. Northern populations of Chinook salmon (e.g., Yukon River) are also renowned for their high fat (lipid) content, making them a potentially valuable food resource for marine mammals, birds, fish, and humans in the Bering Sea ecosystem. High lipid storage may enhance the ability of Chinook salmon to survive prolonged periods of poor ocean conditions. We hypothesize that survival of Chinook salmon in the Bering Sea is linked to their energetics (food, metabolism, growth) in winter, their diets and growth during peak summer feeding periods, and their nutritional (lipid) status in fall. Interannual variation in salmon survival is associated with the synoptic type of winter (cold or warm). Our goal is to identify physical and physiological factors that affect winter survival of Chinook salmon in the Bering Sea. We present preliminary results from our first fall field sampling of Chinook bycatch from southeastern Bering Sea trawl fisheries. Lipids were measured with a lipid (fat) meter which estimates water content of the fish based on the attenuation of microwave signals. Whole fish homogenates were dried, and moisture content and caloric values were determined. Moisture content and lipid meter measurements were closely correlated with each other and with the size of fish. Future field sampling will take place near the end of winter.

Ichthyophonus in Chinook salmon - The marine face of a freshwater problem

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Ichthyophonus hoferi is a marine-derived parasite of various teleost species, including Chinook salmon (*Oncorhynchus tshawytscha*). Salmon stocks in Western Alaska are declining for yet unknown reasons, and involvement of disease in these declines cannot be ruled out either due to pathogen-induced mortality, reduced fecundity, or the inability of Chinook salmon to successfully migrate and spawn in tributaries. Chinook salmon is a staple of Alaska's fishery and low abundance has led to economic hardships for communities dependent upon them. *Ichthyophonus* undergoes cyclic prevalence changes in the freshwater phase of Chinook salmon that are likely correlated to marine ocean temperatures and conditions, yet little is known about the parasite in salmonids during their marine phase. Collaboration with seafood processors in Dutch Harbor made it possible to obtain samples from Chinook salmon by-caught in the A-season of the Pollock fishery in 2010. A total of 393 samples were collected ranging in total length from less than 250mm to 939mm with 59.5% of fish being female. Presence/absence of *Ichthyophonus* 18S rDNA was determined using PCR. Prevalence of *Ichthyophonus* in salmon cardiac tissue was 1% (4 of 393) and is an order of magnitude lower than prevalence of the parasite in Chinook salmon entering the Yukon River. This suggests that *Ichthyophonus* is acquired by the host shortly before river entry possibly during gorging on prey resources in preparation for migration.

Aleutian Archipelago nearshore fish communities: a result of oceanographic and kelp forest factors

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Communities of kelp forest fishes respond to habitat variability. Often responses can induce regional scale changes in distribution patterns. In the Aleutians, oceanographic conditions and indirect effects of sea otter abundance can cause habitat variability. Biogeographic breaks in marine fauna along the island chain have been described based on deep, offshore surveys and attributed to the surrounding oceanography. However, the majority of scientific effort in the nearshore system has been focused on the algae, urchin, and otter paradigm. A detailed survey of kelp forest fishes and their habitat are the missing feature in both of these system wide examinations. The objectives of this study were to assess the current state of kelp forest fish community structure along the Aleutian Archipelago, determine what habitat characteristics might be important to these fishes, and see if the observed communities corroborate published biogeographic breaks. To address these objectives diver based visual transect surveys were performed at 30 sites from Unalaska Island to Attu Island, Alaska. Two, 100 m^2 transects were run at each site, recording fish biodiversity and abundance as well as physical and biological habitat characteristics. Multivariate analysis showed distinct breaks in the abundances of gadids, sculpins and rockfish, as well as, several habitat parameters. The biogeographic breaks found in these surveys agree with those described from offshore studies using oceanographic variables; though analysis suggests that habitat variation caused by the current sea otter decline is also influencing fish assemblages.

Age-1 walleye pollock in the eastern Bering Sea: distribution, abundance, diet, and energy density

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Juvenile pollock make up a large component of biomass of the pelagic foragers in the eastern Bering Sea. Many studies have focused on age-0 pollock and while fewer studies examine age-1 pollock, yet the path to recruitment into the fishery remains unclear and correlation between juvenile and adult abundance is low. In addition to improving the current scarcity of data, exploration of age-1 pollock may provide key insights into the potential effects of the oscillating control hypothesis (OCH) in the eastern Bering Sea. Recent evidence suggests that certain OCH conditions that favor pelagic productivity may actually negatively affect recruitment of age-0 to age-1 pollock due to the absence of large lipid-rich zooplankton. During 2004 to 2010, the BASIS stations were sampled with a pelagic trawl (e.g., surface and mid-water) from mid-August to early-October. We present the distribution, abundance, and diet of age-1 pollock in the eastern Bering Sea during this period. In addition we evaluate the energy density of age-1 pollock in 2008, 2009, and 2010 from BASIS and MACE surveys and provide evidence that energy density in age-1 pollock is increasing between summer and fall. This is preliminary work in preparation of a more thorough comparison between age-0 and age-1 pollock that will compare their trophic status and potential as ecosystem indicators.

Distributional stability of age-0 Pacific cod cohorts in the eastern Bering Sea under variable recruitment and thermal conditions

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Despite the importance of Pacific cod in Bering Sea fisheries and food webs, little is known about the ecology of early life stages including the habitat use and distribution of juveniles. In this study, we examined patterns in basin-scale distribution in juvenile (age-0) Pacific cod through an analysis of catches in the Bering-Aleutian Salmon International Survey (BASIS) for the 2004 to 2009 cohorts. We were specifically interested in examining the potential for distributional response to cohort strength and temperature variation. Pacific cod collected in mid-August to mid-September were most commonly captured on the middle shelf, over depths of 50-80 m and were rarely captured north of 60°N. Two areas with consistently high catch rates (> 100 fish per tow) were identified: east of the Pribilof Islands and north of Port Moller on the Alaska Peninsula. Interannual variation in CPUE in six regions was used to explore patterns in distribution. There was evidence of density-dependent habitat selection at the local scale as the frequency of occurrence of juvenile Pacific cod was significantly correlated with regional CPUE. However at the basin-scale, there was no evidence that cohort strength impacted overall distribution in the Bering Sea. Annual mean temperature of capture varied among years from 8.8°C in 2008 and 14.9°C in 2005 and was positively correlated with mean temperatures measured during sampling. Annual mean latitude of capture was not correlated with thermal variation prior to or during the sampling period suggesting that distribution of juvenile Pacific cod did not shift with short-term climate variability. The results observed for Pacific cod contrast those observed for walleye pollock, which appears to exhibit greater variance in distribution, but are similar to patterns observed for juvenile Atlantic cod. Future work should focus on the inshore distribution of juvenile cod and examine patterns of dispersal within the Bering Sea population and exchange with the adjacent Gulf of Alaska population.

Diet and Reproductive Status of Snow Crabs in the Northern Bering Sea

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The center of abundance for mature female snow crabs and males of marketable size has shifted to the northwest, away from historical fishing areas in the southeastern Bering Sea. Although NOAA surveyed stations in the Northern Bering Sea Research Area in 2010, very few data exist on the demography, diets, and reproductive status of snow crabs between St. Matthew Island and the Bering Strait. We are characterizing the diets of snow crabs in this large region through stomach content, stable isotope, and fatty acid analyses. Stomach contents have indicated a diverse diet for snow crabs of all sizes in all parts of our study area. Juvenile crabs (<20 mm carapace width) focused on softer, more easily manipulated prey such as amphipods and small bivalves with thin or incompletely calcified shells. Larger crabs consumed larger prey such as harder-shelled bivalves and gastropods that require greater handling ability and claw strength. Mature female crabs were essentially absent from stations in the Chirikov Basin, and occurred at highest densities at our southernmost stations south of St. Lawrence Island. Most mature females collected appeared to be primiparous, bearing a clutch of bright-orange, uneyed eggs. Multiparous females were uncommon in our study area, as were mature males, potentially due to a southeastward, ontogenetic migration by crabs of both sexes. Clutch size increased dramatically with carapace width, and was higher in multiparous than in primiparous females of the same carapace width interval. The small size attained by mature female crabs in our study area, and their biennial reproductive schedule, greatly reduce their fecundity compared to larger females in the south.

Variability in reproductive potential of eastern Bering Sea snow crab, *Chionoecetes opilio*, in relation to spawning stock demography and temperature

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Biomass-based reference points currently used in management of eastern Bering Sea snow crab, *Chionoecetes opilio*, may be insensitive to demographic variability that results in variation in the annual production of viable embryos. To develop improved indices of reproductive potential, we measured fecundity of mature female snow collected during the eastern Bering Sea bottom trawl surveys in 2007 and 2008. Snow crab fecundity differed significantly between primiparous (brooding first egg clutch) and multiparous (brooding second or subsequent egg clutch) females. Among multiparous females, fecundity decreased with increasing age, as inferred from shell condition. We developed an index of egg production that incorporates differences in fecundity with shell condition, the estimated proportion of mature females on a biennial cycle of embryo incubation (<0° C), and the observed proportion of females without egg clutches from bottom trawl survey data from 1978 to 2008. Stock demography (shell-condition structure) fluctuated temporally with year-class strength as abundant cohorts aged through the mature female population. Primiparous and young multiparous females represented a high mean proportion (81%) of total mature female abundance. Primiparous females were more frequently observed at bottom temperatures <0° C than multiparous females, inferring a higher likelihood of biennial egg production for primiparous females. Incorporating these factors into the egg production index demonstrated decreased stock reproductive potential from 1993 to 1998 and 2003 to 2008, primarily due to an increased proportion of primiparous and young multiparous females on a biennial reproductive cycle.

Using sponge morpho-groups to examine *Sebastes alutus* associations with living substrata in cold-water habitats (Aleutian Islands, Alaska)

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Two life stages of *Sebastes alutus* have different associations with living substrata (e.g., adults are found schooling over sea whip forests whereas juvenile aggregations are correlated with sponge and coral abundance). Sponges and corals comprise a persistently large and taxonomically complex fraction of survey catches from the Aleutians (over 100 sponge taxa have been identified from this region). We categorized all Aleutian sponge taxa into 16 different morpho-groups and used generalized additive models (GAMs) to predict separately the presence-absence and conditional abundance of S. alutus in response to observed patterns of sponge and coral presence-absence in the context of several environmental parameters (i.e., depth, temperature, bottom slope, and tidal velocity). The juvenile *S. alutus* GAMs explained 34% of the variability in their presence-absence and 20% of the deviance in conditional abundance. They were more likely to occur in the presence of corals and four sponge morphs (globular, vase, flabellate, and undifferentiated Porifera) and were collected in higher abundance when corals and repent sponges were present. The GAMs for adults explained 37% of the deviance for both presence-absence and conditional abundance, and showed that adult response to the presence of corals and sponge morphs was negatively correlated. Our results suggest that corals and repent sponge morph may provide important juvenile *S. alutus* habitat while confirming previous findings that sponge assemblage complexity and biomass also play a role. These results also suggest that aggregations of adult Pacific ocean perch are found in areas without large or complex assemblages of corals and sponges.

Effects of the age composition of spawning sockeye salmon on future returns of sockeye salmon to Bristol Bay, Alaska

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Despite the vast amount of salmon research, little is known about the influence of spawner age composition on future recruits. The age structure of sockeye salmon on spawning grounds is highly variable, and the impacts of this variability are not well understood. The Bristol Bay sockeye salmon fishery uses only the number of spawners to determine escapement goals, without regard to age or size composition. This may not adequately reflect reproductive potential. We include spawner age composition as a predictor variable in a set of statistical models in order to see how the parental age structure affects the age composition of their progeny. In addition, we examine the relationship between spawner age composition and the overall abundance of recruits. We found a direct relationship between the age composition of spawners and that of their progeny. We also found environmental effects on age composition. A higher proportion of spawners that spent three years in the ocean were associated with a higher proportion of recruits with a similar life history pattern. Redefining spawner-recruit models based on spawner age composition did not significantly improve the ability to predict abundance of recruits. This work provides insight into sockeye salmon biology, and shows the impacts of varying age composition on the sockeye salmon fishery of Bristol Bay, Alaska.

Recruitment mechanisms of eastern Bering Sea Tanner crab, *Chionoecetes bairdi*

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The Tanner crab, *Chionoecetes bairdi*, has been subject to large scale variance in total adult abundance and fishery recruitment in the eastern Bering Sea (EBS) region. Possible mechanisms responsible for these fluctuations are of significant ecological and economic interest, due to the scale of the variability and its economic impact on regional communities. The objective of this study was to elucidate potential biophysical mechanisms which may regulate survival of larval and juvenile *C. bairdi*, as it is believed that these are the stages at which the responsible mortality events occur. Statistical analyses were conducted using generalized least squares (GLS) methodologies and incorporating corrections for first order autocorrelation. Mechanisms investigated included abundances of Pacific cod, yellowfin sole and flathead sole, mature female *C.bairdi* abundance, mean bottom temperature (MBT), wind component vector and sea surface temperature (SST). These mechanisms were compared against juvenile recruitment to the 30-50mm carapace width size range. Preliminary results suggest that contrary to the initial hypotheses a strongly negative stock-recruit relationship occurs and positive relationships were observed between recruitment and groundfish abundance. Results for the wind component analyses conformed to the initial hypotheses. Finally, MBT and SST do not appear to influence recruitment. Based on these results, it was concluded that of the variables examined, only wind vector and spawning female abundance offered evidence of influencing recruitment to the juvenile index. If these preliminary conclusions hold following final analyses, they will be of significant use to managers for predicting near-future trends in the population and managing for them.

Seasonal patterns of energy content and allocation in walleye pollock (*Theragra chalcogramma*)

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Walleye pollock (*Theragra chalcogramma*) support the largest commercial fishery in the United States and are an ecologically important component of the eastern Bering Sea (EBS) ecosystem. Multiple forcing mechanisms during the early life stages of pollock result in variable recruitment, from local hydrography at spawning sites to basin-scale climatic conditions. Relating the seasonal progression of energy content and allocation to the distribution and abundance of pollock allows for detection of spatial and temporal trends in pollock condition and provides critical information for the prediction of overwinter survival and recruitment to age-1. Larval, juvenile, and age-1 pollock were collected in the EBS from May to September 2008-2010. Fish condition was determined through quantification of energy density (kJ/g) and proximate composition (% lipid, protein, moisture) with variation in energy density driven by variability in percent lipid. Energy densities were relatively low during larval development in June/July of 2008 and 2009 (17.5 ± 0.73 kJ/g dry mass [mean ± SD]), but lipid acquisition rates increased ten fold as pollock reached the juvenile form leading to higher energy densities (23.03 ± 0.49 kJ/g dry mass [mean ± SD]) in September. A physiologically and ecologically important shift occurs after larval development is complete (~25mm SL) when pollock begin allocating energy reserves to storage for overwinter survival. Fall condition of juvenile pollock is increasingly recognized as a predictor of recruitment to age-1; we hypothesize fall condition is dependent on oceanographic conditions and prey availability during a short critical period in early fall for lipid storage.

Sperm reserves of female snow crab (*Chionoecetes opilio*) in the eastern Bering Sea: preliminary results of a monitoring study

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Snow crabs (*Chionoecetes opilio*) support a commercially-important fishery in the eastern Bering Sea (EBS), where males of a minimum legal size are harvested. Female snow crabs have sperm storage organs. If females receive sufficient sperm reserves during mating, they can produce fertilized egg clutches over multiple reproductive cycles. This factor along with male polygyny could buffer the stock from low recruitment if females had limited access to males during mating. A monitoring study was initiated in 2005 to better understand the role female sperm reserves may play in this stock. Spermathecal load (SL) of primiparous snow crab from 2005 – 2010 ranged from 0 to 0.5600 g and averaged 0.0415 g (n = 818, SE = 0.0018). Significant relationships (ANOVA, $p<0.01$) were detected between SL and female size, year, and area of collection (as defined in three regions), as well as interactions among those factors. The highest levels of SL were observed in the southeast area in 2007 and 2008 and the lowest levels were observed in the northwest area in each year. Female sperm reserves in primiparous snow crab from the EBS are relatively low in comparison to levels reported from the Northwest Atlantic. Though estimates of egg viability indicated the majority of crabs in our study received sufficient sperm during mating to fully fertilize their first clutch, levels indicate that many would need to re-mate prior to producing subsequent fertilized egg clutches. Spatial trends observed underscore the importance of understanding how spatial processes affect the EBS snow crab stock.

Salmon in Schools: science and cultural education that swims

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4-H has been successful by tailoring its programs to fit the communities and youth they work with. The Alaska 4-H Natural Resource and Youth Development Program (NRYD) has been serving the needs of youth from rural communities across the state since 1991. Originally developed to provide fisheries education to youth in 8 communities impacted by declining salmon returns in the early 1990's on the Yukon River, it has grown to embrace a variety of natural resource issues vital to rural residents in over 70 communities.

NRYD program strategies include: the focus on salmon as a resource of cultural relevance; place-based, culturally-relevant teaching methods and resources integrating Alaska Native knowledge; positive youth development; and professional development opportunities for rural educators. Its greatest impacts are realized through high quality training incorporating each of these strategies at annual teacher inservices.

Program success has also been a result of many partnerships, including ADFG, the USF&WS, and Native organizations. In 2009, Alaska Sea Grant began providing funds for teachers and resources for a focus on the ocean phase of the salmon life cycle and climate change. COSEE Alaska began engaging scientists in the teacher workshops to provide current research and to foster teacher-scientist partnerships.

The additional resources are meeting needs of Alaskan teachers for ocean and climate change education training and resources identified in a 2010 survey (COSEE Alaska and IARC, unpub. data). Eight scientists have achieved the broader impacts of their research by increasing teacher knowledge about important topics of ocean and climate change literacy through the lens of one of Alaska's most important natural resources.

Feeding Patterns and Potential Dietary Overlap of Age-0 Pelagic Larvae and Juveniles of Walleye Pollock (*Theragra chalcogramma*) and Pacific Cod (*Gadus macrocephalus*)

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The goal of this study is to examine and compare feeding patterns of pelagic larval and juvenile walleye pollock (*Theragra chalcogramma*) and Pacific cod (*Gadus macrocephalus*), collected in spring, early summer, and fall of 2008, an exceptionally cold year, on a large scale station grid covering the eastern Bering Sea from Unimak Pass to the vicinity of St. Lawrence Island. Previous studies have found that growth, and thus feeding success during the first summer are important conditions for overwinter survival and, subsequently, recruitment success of marine fishes. This study will benefit greatly from available data on zooplankton abundance, composition, and biomass which were collected as part of the Bering Sea Fisheries Oceanography Cooperative Investigations (Bering Sea FOCI) in spring, the Bering Ecosystem Studies (BEST) and the Bering Sea Integrated Research Project (BSIERP) in early summer and the Bering Aleutian Salmon International Survey (BASIS) cruises in the fall, respectively. As part of this study, we will quantify feeding success, prey selection, and potential dietary overlap. Results from this study will provide first insight into resource allocation and the potential for dietary overlap and may allow the assessment of the probability of food competition between early pelagic life stages of walleye pollock and Pacific cod prior to their first winter during an exceptionally cold year in the eastern Bering Sea.

Does maternal size affect red king crab (*Paralithodes camtschaticus*) recruitment potential due to embryo or larval production?

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Stock assessment and management of Alaskan red king crab *Paralithodes camtschaticus* do not incorporate recruitment potential based on embryo or larval production. Estimates of fecundity and indices of embryo and larval quality as a function of maternal size may rectify this situation. Fecundity increases with maternal size, but embryo loss may occur over the ~12 month brooding period. Between 2007 and 2009, fecundities of small (<105 mm carapace length, CL) and large (≥ 105 mm CL) females were compared during early (summer) and late (fall) brooding periods. Among small females, no clear seasonal pattern was observed with fecundities ranging from 16.7% significantly lower fall fecundity, no seasonal difference, and 11.8% significantly higher fall fecundity. Large females were 4.8-8.2% significantly less fecund in fall than summer, suggesting embryo loss during brooding. In 2009 and 2010, embryo quality based on dry mass, carbon content and nitrogen content was assessed from females 86-145 mm CL. Among these measures of quality, only nitrogen content significantly increased with maternal size. Carbon and nitrogen content were significantly higher for embryos in 2009, suggesting interannual differences in maternal investment. In 2008, larval quality based on dry mass, carbon and nitrogen content, and time to 50% mortality under starvation conditions was assessed as a function of maternal size from crab 93-135 mm CL. No effect of maternal size with larval quality was found. Among the factors considered, maternal size influences on fecundity and embryo loss are the most important to incorporate into recruitment potential estimates for stock assessments.

Competition dominates multi-species interactions between gadoids and arrowtooth flounder in the eastern Bering Sea ecosystem

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Interactions among some commercially important fishes in the eastern Bering Sea, and potential management implications were studied using multi-species biomass-dynamics models. We aggregated the observed biomass of seven fish species into three groups (gadoids, arrowtooth flounder, and other flatfishes). Biological reference points (MSY, FMSY) were first estimated for each group by fitting a biomass-dynamics model to aggregated biomass and commercial catch data. We then developed a multi-species version that included interaction terms for competition and predation, connecting biomass equations among the three groups. Alternative models using different combinations of interactions were compared using the Akaike Information Criterion to select the best model and to identify the most important interactions. Using parameter estimates from the best model, biomasses and harvests were projected to find the equilibrium biomass and yield for each and for all groups combined. We found a significant negative effect of competition by arrowtooth flounder on gadoid biomass, suggesting that competition may be more important than predation in the interactions between gadoids and arrowtooth flounder. A continuous increase of arrowtooth flounder biomass in the eastern Bering Sea in the past 30 years resulted in significant loss of gadoid biomass annually. The estimated loss of gadoid biomass caused by competition has exceeded the commercial harvest since 1994. As a result, equilibrium yields of gadoids, and of gadoids and arrowtooth flounder combined, were significantly lower compared to single-species predictions. Gadoid yields were maximized only by the unrealistic reduction of arrowtooth flounder to a biomass of about 0.25% of its carrying capacity.

Prediction of bycatch mortality based on reflex impairment during the commercial snow crab (*Chionoecetes opilio*) fishery

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The mortality of the non-retained crab during a commercial crab fishery in the eastern Bering Sea must be included as part of the total catch removal calculations used to calculate harvest levels. Best available information estimates the crab bycatch mortality to be 50% in pot fisheries but it is widely acknowledged that further refinement of this estimate is needed. To accomplish that goal, the Reflex Action Mortality Predictor (RAMP) method was applied to snow crab discarded during the 2009/2010 commercial fishing season. The RAMP method evaluates the responses of the crab to a set of six reflexes. These reflex responses have been shown to accurately predict mortality in 91% of snow crabs. Biologists were placed on board commercial fishing vessels where they assessed sublegal males and female snow crab reflexes just prior to being returned to the sea.

Reflexes from over 12,000 crabs were evaluated, representing 22 different vessels. Sampling occurred from January to April of 2010. Crabs exhibited relatively low levels of reflex impairment from the sorting and discard process during mild weather conditions. Reflex impairments and the associated predicted mortality increased sharply, however, with decreasing windchill (less than -10 degrees C). Although additional observations are needed during the most severe conditions, this study is a first step in improving the bycatch mortality estimate needed to calculate crab harvest levels in the eastern Bering Sea.

Estimation of survival rates for branded Steller sea lions on the Kuril Islands, Russia

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To monitor current demographics of SSL, permanent marking using hot-iron branding was conducted on five major rookeries in the Kuril Islands beginning in 1989. We analyzed 4794 recapture events of 3547 branded SSL pups from four rookeries. Survey effort between 1990 and 2001 was low so recapture probability was less than 0.1. Starting in 2002 we monitored each rookery for up to two months during the breeding season, which increased recapture probability to 0.4 - 0.9. To estimate survival rates we used the Cormack-Jolly-Seber model. Survival rates for the pups were lower compared with other ages and ranged 0.5-0.6 across all rookeries. Pup survival was a little higher on the central Kurils at Lovushki (0.62 se=0.03) and Raykoke (0.61 se=0.03) in comparison with Antsiferov (0.54 se = 0.03) and Brat Chirpoev (0.57 se=0.03), but these differences were insignificant. For animals aged 1+ estimated survival rates (~0.8-0.9) were higher than for pups and did not differ significantly between rookeries. Survival rates of all age groups did not change significantly over the last 8 years, but had slightly positive trend. Our survival estimations combined with observed reproductive rates and abundance trends suggest slowly population grow in the Kuril Islands in the near future, if environmental conditions do not change dramatically.

Contrasting fine scale foraging behavior of northern fur seals (*Callorhinus ursinus*) from two Bering Sea islands with dramatically different population trends

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Northern fur seal populations on St Paul Island continue to decrease while numbers on Bogoslof Island increase dramatically. Foraging times of the fur seals from the two islands are known to differ considerably (i.e. average foraging trip is ~3 days for Bogoslof and ~7 days for St. Paul), but detailed understanding of how and where they feed is unknown due to limitations of tracking technology. We sought to fill in this gap in knowledge by deploying 90, 1st generation Wildlife Computers Mk10 Daily Diary tags (containing 3 dimensional accelerometers and magnetometers as well as temperature and depth sensors) on lactating northern fur seals on St. Paul and Bogoslof Islands in the summer of 2009. The Daily Diary units recorded data 16 times a second to determine location and relative activity. This promises to give us insight into the activity budgets, foraging behavior and energy expenditure of northern fur seals and may indicate differences in these factors that will help explain the disturbing declines on St Paul Island and the dramatic increases at Bogoslof.

The Alaska Marine Mammal Tissue Archival Project: Long-Term Specimen Banking for Environmental Monitoring

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The Alaska Marine Mammal Tissue Archival Project (AMMTAP) is an ongoing project that began in 1987. The goal of AMMTAP is to develop a repository of marine mammal tissues that are suitable for determining exposure to anthropogenic contaminants and to maintain these tissues under conditions of long-term ultra-cold preservation. The AMMTAP collection provides samples for future studies of newly recognized contaminants to determine how long biota have been exposed to such chemicals and whether this exposure has changed over time. Over the years, AMMTAP received funding from the Minerals Management Service, National Oceanic and Atmospheric Administration, U.S. Geological Survey Biological Resources Division, National Institute of Standards and Technology, and U.S. Fish and Wildlife Service. The harvest of marine mammals by Alaska Natives for subsistence has been the primary source of tissues for AMMTAP; thus, many different Alaska Native organizations and individuals have been important collaborators of AMMTAP. Over the years, AMMTAP samples have provided information on levels of heavy metals and persistent organic pollutants in beluga whales, bowhead whales, polar bears, northern fur seals, bearded seals, ringed seals, and walrus. Recently, AMMTAP samples were used for investigating time trends in exposure of Alaska beluga whales to chemicals of emerging environmental concern, including brominated flame retardants and perfluorinated compounds. Tissues collected by AMMTAP over a period of 20 years at St. Paul Island are presently being used to determine the long-term trends in metals, legacy persistent organic pollutants, brominated flame retardants and perfluorinated compounds in northern furs seals. The evolution of AMMTAP since 1987 is described and possible new directions for the Project are discussed.

Foraging ecology of lactating northern fur seals (*Callorhinus ursinus*) on the Commander Islands

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Lactating northern fur seals (NFS) are income breeding, central-place foragers that have limited time to feed before needing to return to the rookery to nurse their pup. Therefore, prey abundance near rookeries is a key factor in pup weaning. Data on 83 foraging trips were collected in 2003, 2004, 2008 and 2009 from 23 lactating NFS from Severo-Zapadnoe rookery on Bering Island (Commander Islands). Dives ≤5m and ≤ 0.5min were classified as travelling dives and excluded from subsequent analyses. There were no interannual differences in the size of females (mean mass=39±5 kg; mean SL=132 ±7cm). The mean duration of foraging trips was almost equal in different years (mean 3.4 ± 1.4 days). In 2003, 2004, and 2009 the first foraging trip ranged between 1 -6 days, (mean 3.3±1.3 d), but was significantly longer in 2008 (mean=5.1±1.6d, range 2 - 8 d; p=0.02). The mean maximum dive depths were also similar in most years (mean 14.0±5.0 m), although in 2008 there was a significant but small and likely negligible difference. The years 2001-2005 were oceanographically “warm” years, but changed to cooler conditions in 2007. To determine how this may have affected the local food web, hard parts from 270 scats and spews of juvenile NFS males were identified. The frequency of occurrence of Hexagramidae (from 0.86% to 36.4%), Ammodytidae (from 28.4 % to 6.3%) and Bathyteuthidae changed dramatically over the period. Despite changes in local prey and oceanographic conditions, there seemed to be little impact on NFS lactating female foraging behavior.

Local factors affecting subsistence walrus harvest on Saint Lawrence Island

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Saint Lawrence Island is located in the Bering Sea 60 kilometers south west of the Chukotka Peninsula (Russia) and contains two predominately native villages, Gambell and Savoonga. Over the past five years (2005 – 2009) the reported subsistence walrus harvest from Gambell and Savoonga on Saint Lawrence Island accounts for 92 percent of the total reported Alaska harvest, indicating the importance of walrus to the two communities. We examine the timing of the subsistence harvest and several local factors that affect this harvest at Gambell and Savoonga. We examine harvest methods, self-regulation, weather conditions, economics and factors that may compete with the harvest. Using recent harvest records we are able to look at harvest chronology and define the conditions that are needed for an optimal harvest in both Gambell and Savoonga.

Aren't Steller sea lions wintering in the Commander Islands anymore?

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Steller sea lions (SSL) bred and were abundant on the Commander Islands in 1741 when George Steller wrote that SSL were more abundant in summer than winter. By mid 19th century, SSL stopped breeding there and were locally extinct by the end of the century, apparently due to unregulated harvest. In the early 20th century SSL increased and by the 1950's they inhabited the area year-round. Throughout the 20th century SSL were more abundant in winter than summer. Data on SSL abundance in late fall-winter-early spring is scarce. In summer 2010, there were 500-600 non-pup SSL. After a 20% decline in pup production in 2009, pup numbers returned to close to the average annual level (222 pups in 2010). After a 20-year gap of fall observations on Medny Island, surveys were conducted from summer through November 2010. SSL rapidly decreased in October and they all unexpectedly departed in early November. This abandonment of Medny Island in fall had not been documented over the last 100 years. Only 20-30 SSL hauled out in early November 2010 at the NW end of Bering Island. In 2009, SSL left NW Bering Island in early December. The cause of the shift in seasonal habitat use in the Commander Islands is unknown, but could be due to seasonal changes in prey abundance and distribution. The Commander Islands has been protected by a 30 mile wide no-fishing zone since the late 1950s, so the change is not likely related to local commercial fishing.

HISTOLOGIC LESIONS IN NORTHERN FUR SEAL (*CALLORHINUS URSINUS*) PLACENTAS, ST. PAUL ISLAND, ALASKA

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The Northern fur seal (*Callorhinus ursinus*) population has been declining for the last 30 years. One hypothesis has been attributed to a decline in pup production. Numerous studies have explored causes of mortality in pups and adults but infectious disease does not appear to be a significant risk factor. Placental insufficiency or placental infection in any species commonly results in abortion, stillbirths or weak offspring; as such, placental health warrants investigation in populations with poor recruitment. To investigate problems related to placentation, fresh placentas were collected at Reef Rookery on St. Paul Island, Alaska from 9 July to 10 August 2010. Histologic changes observed included physiologic necrosis and rare inflammation. Infectious disease testing to date will be described. Consistent with other findings, placental pathology and infection does not appear to be a significant risk factor for population decline within this species.

Cetacean Distribution in the Bering Sea in the Summer 2008 and 2010

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As part of the Bering Sea Project, cetacean surveys were conducted to describe abundance and distribution on the SE Bering Sea shelf. Three marine mammal observers conducted visual surveys along transect lines sampled during the NOAA walleye pollock assessment survey in June and July of 2008 and 2010. Cetacean sightings (2008, 2010) included fin (78, 60), humpback (46, 39), minke (7, 21), sei (1, 1), gray (1,0), sperm (4, 6), killer (35, 23), and Baird's beaked (2, 1) whales, harbor (55, 11) and Dall's (171, 93) porpoise, and Pacific white sided dolphins (0, 2). Distribution in 2008 and 2010 is compared to sightings from a similar survey conducted in 2002; patterns largely match those previously observed. Fin whales were found in the middle and outer domains; the concentration of their distribution was shifted west in 2002 and east in 2008 and 2010. Humpback whales were concentrated in coastal waters north of Unimak Pass and, in 2010, along the slope around 58.5°N. Minke whales were also found north of this location in 2010. Minke whales were concentrated in the outer domain except for 2002 when they were also found east of the Pribilof Islands. Killer whales and Dall's porpoise were found primarily in the outer domain. Harbor porpoise distribution was different in each year. Effort in 2010 was greatly reduced due to weather conditions. In all years, many sightings couldn't be identified to species due to adherence to the pollock survey tracklines pointing to the need for dedicated cetacean surveys.

An investigation of northern fur seal (*Callorhinus ursinus*) pup entanglement in relation to local marine debris beach cleanups on St. George Island, Alaska

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Entanglement in marine debris can adversely impact marine mammal populations and has been implicated in the decline of northern fur seals on the Pribilof Islands. Northern fur seals are particularly vulnerable to marine debris at a young age. Increased funding has been allocated in recent years for marine debris cleanups, however the assumption that a reduction in the amount of debris in fur seal breeding habitat will result in a decrease in fur seal entanglement has not been critically evaluated. Fur seal pups may be a useful indicator of the impact of nearshore debris because they do not travel far from shore prior to weaning. This project tests whether cleaning a beach of marine debris is followed by a reduction in the observed entanglement of northern fur seal pups at a study site on the Pribilof Islands and whether the incidence of entanglement of fur seal pups may be a reliable proxy for the success of local marine debris cleanups. In May of 2009 and 2010, South Rookery on St. George Island was completely cleaned of marine debris. Debris was sorted into types commonly observed entangling seals (primarily nets and packing bands) and measured and identified for the purpose of assessing near-shore debris composition. From 2005-08, the annual incidence of pup entanglement was estimated using visual surveys conducted during August - November (mean entanglement rate- .06-.08%). Data from comparable surveys conducted during the 2009 and 2010 breeding seasons will be used to evaluate whether pup entanglement decreased following debris cleanups.

Changes in northern fur seal (*Callorhinus ursinus*) foraging behavior with dramatically increasing population density

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The recent colonization of Bogoslof Island (Alaska) by northern fur seals provided a unique opportunity to examine the impact of increasing population density on the at-sea behavior of a central place foraging pinniped. Since 1980, when the first two pups were recorded, the population has grown 43% per year with 17,574 ± 843 pups born in 2007. While growth continues, recent counts (2005 and 2007) show a slowing to approximately 13.0% per year. To examine how this rapid increase in population density impacted individual foraging behavior, 50 female fur seals were tracked using time-depth recorders and satellite transmitters in 1997, 2005, and 2006. Dive bouts were not different among years and were characterized by short (44.3 ± 30.1 s), shallow dives (11.7 ± 8.2 m). Females increased the percent time spent at sea by 29% between 1997 and 2005/2006 (51.1 ± 0.1%, 65.9 ± 0.03% and 67.2 ± 0.05%, respectively). From 1997 to 2005, trip durations nearly doubled (1.2 ± 0.8 d vs. 2.1 ± 0.5 d) and maximum distance travelled increased (51.2 ± 44.3 km vs. 137.3 ± 17.8 km); but both parameters remained consistent between 2005 and 2006. Finally, total foraging area increased over 400% from 1997 to 2005/2006. The increased foraging area and time at sea combined with the recent slowing of population growth suggest that increased intraspecific competition may have led to localized resource depletion around Bogoslof Island. However, Bogoslof Island fur seals still expend significantly lower foraging effort compared to other larger local colonies, which are currently declining. For example, in 2006, St. Paul Island fur seals spent over 77% of their time at sea, travelled twice the maximum distance (> 300 km), and had trips that were 2.6 times longer than Bogoslof Island fur seals. As northern fur seals are listed as depleted, comparisons between Bogoslof Island and declining colonies with greater foraging effort may provide important insight for determining conservation goals for this species.

Linking foraging northern fur seals (*Callorhinus ursinus*) with fine-scale oceanographic features: contrasting attributes from islands with opposing population trends

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Northern fur seals breeding in the eastern Bering Sea are declining at the Pribilof Islands (St. Paul and St. George Islands) and increasing at Bogoslof Island. The marked divergence in population trajectories may be linked to regional differences in ocean productivity created by dynamic oceanographic features such as temperature structure and fronts. We sought to identify the physical mechanisms controlling summer feeding by northern fur seals by collecting and analyzing environmental parameters where fur seals are actually foraging, and relate them to differences in population sizes and trajectories. We deployed Wildlife Computers Mk-10 “F” tags on 87 lactating northern fur seals (44 St. Paul, 43 Bogoslof) during July – September, 2009. Water temperature and depth were recorded every second for 173,348 dives, allowing for high-resolution reconstruction of the water column along GPS-derived foraging tracks. No overlap in foraging areas was detected between St. Paul and Bogoslof populations despite the potential for range overlap. First passage time analysis (FPT) indicated that St. Paul animals doubled their foraging scale (mean radius = 12 km) compared to Bogoslof seals (mean radius = 6km). Appropriately scaled environmental covariates such as temperature, mixed layer depths, bathymetry, and filament structure will be tested using Cox-proportional hazard models to evaluate their influence on northern fur seal foraging patterns, which in turn ultimately affects population trends for this piscivorous top-predator.

Relative importance of sea ice algal primary production to Pacific walrus (*Odobenus rosmarus divergens*) diets

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Recent warming in the Arctic lead to substantial changes in sea ice thickness, persistence, and distribution, including record minima in sea ice extent in 2007, 2008, and 2010. Sea ice provides essential habitat for Pacific walruses (*Odobenus rosmarus divergens*), which use the platform for molting, foraging, hauling out, and birthing. Unreliable access to sea ice platforms likely has a direct adverse impact on Pacific walruses. There may be additional indirect effects on the population due to changes in carbon flow through a food web influenced by sea ice algal production. Sea ice contributes from 3 to >50% of the total primary productivity in Arctic seas. The extent to which sea ice algae supports walrus dietary items is unknown. We employed a novel biomarker approach using compound-specific stable carbon isotope analyses (CSIA) on select fatty acids deposited in walrus blubber. Two fatty acid biomarkers (16:4n-1 and 20:5n-3) that originate from marine primary producers were targeted based on their unique δ13C signatures to determine the relative contribution of ice algae and pelagic phytoplankton to walrus diet. Blubber (n = 95) was obtained during subsistence harvests in the summer of 2009 and 2010 in collaboration with the US Fish and Wildlife Service, Eskimo Walrus Commission, and Alaskan Native subsistence users in Gamble and Savoonga. Fatty acids were extracted from full thickness blubber samples and analyzed for stable carbon isotopes. We report these data relative to the isotopic composition of these fatty acids in ice algae and POM.

Impacts of Killer Whale Depredation in the Bering Sea, Aleutian Islands and Western Gulf of Alaska

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Killer whale *Orcinus orca* depredation in Alaska occurs when whales remove fish from demersal longline gear or damage fish or fishing gear. Killer whale depredation is most prevalent in the Bering Sea/ Aleutian Islands and is increasingly problematic in the Western Gulf of Alaska. Overall catch rates can decline by 30% and individual set catch rates by 100% when whales are present. Killer whale depredation results in significant catch reductions in the commercial fishery, leading to fishermen frustration, and may also reduce the accuracy of sablefish or Pacific halibut stock abundance indices. Moreover, these interactions have negative consequences for the whales in the form of increased risk of entanglement and vessel strikes. The goal of this project is to evaluate spatial and temporal trends in killer whale depredation using National Marine Fisheries Service longline survey data from 1995-2009. We will also examine the effects of killer whale depredation on catch rates of depredation target species (sablefish, *Anoplopoma fimbria*, Pacific halibut, *Hippoglossus stenolepsis*, Greenland turbot, *Reinhardtius hippoglossoides* and arrowtooth flounder, *Atheresthes stomias*) and depredation non-target species (Pacific cod, *Gadus macrocephalus* and rockfish, *Sebastes* spp.). Findings from this study will be relevant to future analyses of NOAA longline fishery observer data and will inform the development of regional management strategies to mitigate killer whale depredation impacts on fishermen and longline survey vessels.

Survival at Sea: Young northern fur seals are more susceptible to food disruptions in summer than in winter

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Northern fur seals (*Callorhinus ursinus*) depart the rookery for the first time at around 4 months of age, and remain at sea for the next 18 months. Hence, little is known of their physical development and the factors that may impact their populations during this critical time. Six female fur seal pups from St Paul Island were captured at weaning to measure aspects of bioenergetics under controlled laboratory conditions over their initial pelagic period. Results from a series of longitudinal studies showed pronounced seasonal shifts in the fur seals' energetic priorities. During the winter months, the young fur seals appeared geared towards survival rather than growth. A lack of physical growth was reflected in unusually low metabolic rates compared to other species of young pinnipeds. Voluntary food intake was only marginally higher than basic metabolic costs, and additional food consumption did not translate effectively into body growth. During summer months, there was an emphasis on physical growth, reflected in higher metabolic rates and a greater ability to convert increased food intake into body mass. However, these physiological adjustments for promotion of growth meant that mass loss during periods of nutritional restriction were greater in summer than in winter. This suggests that northern fur seals are keyed to take advantage of predictable seasonal prey resources in summer. However, the higher resulting metabolic overhead due to up-regulating of digestive machinery that facilitates growth in the summer makes them more susceptible to the effects of food disruptions in summer than in winter.

Genetic structure within and among breeding and non-breeding aggregations of Pacific walrus (*Odobenus rosmarus divergens*)

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Pacific walruses occupy shelf waters of the Bering and Chukchi Seas. They form spatially distinct breeding areas and migrate to sexually segregated non-breeding aggregations. Limited information is available on the genetic structure of the Pacific walrus of breeding and non-breeding aggregations. Therefore, we used data from the mitochondrial (mtDNA) and nuclear genomes to assess the genetic relationships among two breeding and six non-breeding aggregations of Pacific walrus. Genetic structure was observed among non-breeding female aggregations across marker types (overall microsatellite FST = 0.019; mtDNA θST = 0.313). In contrast, male aggregations were differentiated only at mtDNA between breeding areas (θST = 0.051), and between East Chukchi and all other non-breeding aggregations (θST = 0.336–0.449). Evolutionary dispersal (gene flow) estimates are asymmetrical from the St. Lawrence into the southeastern Bering breeding aggregation for both sexes. Partitioning of haplotype frequencies among breeding aggregations indicates that individuals may be exhibiting some degree of philopatry. However, this signal is not strong between breeding areas; subdivision was not observed for females. High levels of genetic differentiation observed among East Chukchi and all other nonbreeding aggregations, coupled with considerably lower genetic differentiation between breeding areas, suggests at least one unsampled genetically distinct breeding population may exist. The limited genetic structure between assayed breeding areas, based on nuclear loci, may be attributed to a variety of causes, including extensive gene flow among populations, various aspects of walrus breeding biology, or a prolonged population bottleneck (e.g. commercial exploitation during 1880–1950's) and subsequent recovery.

CAUSES OF MORTALITY IN SUBADULT AND ADULT NORTHERN FUR SEALS (*CALLORHINUS URSINUS*), ST. PAUL ISLAND, ALASKA, 1986 2010

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Northern fur seal (*Callorhinus ursinus*) populations have been declining over the last 30 years on St. Paul Island (57º15'N, 170º20'W), Alaska. To determine whether infectious diseases and on-land mortality of seals may be contributing to the overall decline of northern fur seals; subadult males (n=101), adult females (n=142) and adult males (49) were examined post-mortem from 1986 to 2010 on St. Paul Island, Alaska. Fatal conditions found in subadult males included hyperthermia, blunt trauma, entanglement and bite wounds, whereas nonfatal conditions included seizures, orange discoloration of the blubber, neoplasia and parasitism. Causes of mortality in adult females included bite wounds with cellulitis and secondary infections, dystocia, blunt trauma and neoplasia. Causes of death in adult males were primarily trauma related. Evidence was not found to support the hypothesis that infectious diseases or on-land mortality of subadult males, adult females and adult males regardless of the cause/causes was a major factor in the general overall population decline in northern fur seals.

Testing the nutrition-limitation hypothesis for restricted sea otter habitat use in the Aleutians

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It is speculated that killer whales are the most likely cause of sea otter decline and restricted habitat use in the Aleutian Islands. Causes for habitat limitation have manifested in a debate involving two different processes, bottom-up and top-down forcing. In general, top-down hypotheses provide evidence for predation as the cause for habitat limitation where as bottom-up hypotheses posit the underlying mechanism to be nutritional limitation. To date, nutritional limitation has not been directly tested as a cause for restricted habitat use among sea otter. In this study, two approaches were used to test the hypothesis that sea otter restricted habitat is due to nutritional limitation: (1) comparisons were made between currently used (2008) vs. historically used (early 1990's) sea otter foraging habitats in terms of prey abundance, biomass, and energy density, and (2) comparisons were made between the relative protection from predation afforded by current vs. historic locations (e.g., pinnacles per unit area, channel depth and width, and seafloor rugosity). Results indicate that prey availability and quality are not significantly different between current and historic habitats and that currently used foraging locations are significantly more protected and thus offer greater refuge. Findings from this study provide further evidence for predation as a cause for restricted sea otter habitat use in the North Pacific.

Resource partitioning among sympatric Steller sea lions and northern fur seals on Lovushki Island, Russia

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Steller sea lions (*Eumetopias jubatus*; SSL) and northern fur seals (*Callorhinus ursinus*; NFS) breed sympatrically on Lovushki Island, Russia, creating the potential for inter-specific competition for limited prey resources. Approximately 1,000 SSL and 14,000 NFS breed on Lovushki and an additional 13,000–14,000 juvenile NFS are present during the breeding season. The partitioning of forage resources among SSL and breeding NFS (NFS-B) and non-breeding NFS (NFS-NB) from 2003–2008 was examined through analysis of scats and spews, stable isotope (SI), fatty acids (FA), and telemetry. Scats analysis indicated significant differences between SSL and NFS-B but a significant overlap in the diets of SSL and NFS-NB. SSL fed primarily on Atka mackerel while NFS-B fed primarily on cephalopods and northern smoothtongue. SI analysis indicated SSL foraged at a significantly higher trophic level than NFS-B. Telemetry and SI both indicated that SSL foraged nearshore and benthically and NFS-B foraged offshore and pelagically. FA analysis also indicated significant differences in the diets of SSL and NFS-B. The clear partitioning of forage resources by SSL and NFS-B, both spatially and by prey type, was corroborated on multiple time scales by all four methodologies. The patterns of resource partitioning likely reflected differences in the provisioning strategies of the adults and the fasting abilities of their pups. However, a continued growth of the NFS-NB population may lead to the exclusion of SSL due to competition for prey.

Freshwater Harbor Seals of Lake Iliamna, Alaska. Do they pup and over-winter in the lake?

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Lake Iliamna is home to a small colony of harbor seals (*Phoca vitulina*) which are known to live year-round in the lake. There are no known accounts of immigration or emigration despite access to Bristol Bay via the Kvichak River (120 km in length). Local subsistence hunters harvest small numbers of seals in the early spring when seals haulout along cracks and leads of the frozen lake. There is conflicting information however, regarding when, where, and if seals pup in the lake. We flew six aerial surveys in 2010 to support our ongoing efforts to determine seal abundance, distribution, and seasonal timing. In April, 11 seals were photographed in small shallow-water pools. The lake was completely frozen-over with no visible cracks or leads, and we did not see any areas that could support a population of several hundred seals. In late May only 30 seals (no pups) were observed. In July, 205 seals (including 63 newborn pups) were spotted. Elsewhere in the state we observe harbor seals pupping much earlier, in May and June. In early August, 243 seals (including 55 pups) were seen. By the end of August, the pups had grown to the point where they could no longer be reliably distinguished from adults. The total seal count was 179. Our final survey was in early November. The lake was not frozen and we were only able to locate eight seals. In conclusion, seals do pup in the lake and some seals obviously over-winter, but it seems unlikely that most seals do.

Organochlorine contaminants in Steller sea lion pups (*Eumetopias jubatus*)

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The presence of persistent organic contaminants in the habitats of Steller sea lions (SSL) may influence reproductive rates or possibly survival of SSLs. In particular, the apparent reduction in natality reported by Holmes et al. (2007) for the western stock, is key to the NMFS determination in the draft Biological Opinion (August 2010) that the groundfish fisheries in Alaska may be jeopardizing their recovery. Nonetheless, many constituents have commented on the importance of also looking at contaminants as contributing factors. This project's focus is on the relationship between organochlorine contaminants (OCs) and the recovery of western stock SSL abundance at rookeries in Russian and the USA. OCs were measured in 212 SSL pups in 2002. Of the pups that survived, they should all be reproductively active at this time. The intensive brand resight effort conducted on US and Russian rookeries should provide the opportunity to contrast pup survival, natality, and age of sexual maturity among individuals with low and high post natal loads of OC. These data will be modeled to incorporate spatial and other environmental variables, in addition to contaminant loads. If a positive relationship is found between contaminant load and age specific natality or survival it will help us guide future studies to ascertain the mechanism by which contaminants may be affecting the recovery of SSL. Such a finding would be an important result regarding future management of living marine research.

INDIVIDUAL VARIATION IN MOVEMENTS OF HUMPBACK WHALES (*MEGAPTERA NOVAEANGLIAE*) SATELLITE-TRACKED IN THE BERING SEA DURING SUMMER

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Humpback whales occur in various locations in feeding grounds in the Bering Sea, where their movements and habitat use are poorly understood. In the summers of 2007-2010, eight humpback whales were tagged with PTT-only satellite transmitters near Unalaska Bay (~53°55'N, 166°32'W). Individual whales were tracked for an average of 25 days (range = 4-66 days) and showed substantial variation in movements. Three individuals remained within 50km of their tagging locations for as many as 14 days. Two whales explored presumed feeding areas within 60 km from shore, along the Bering Sea side of Unalaska Bay and Unimak Pass. Two whales moved west; one made a trip to the Island of Four Mountains and returned to the northern side of Umnak Islands and a second whale moved through Umnak Pass and explored feeding areas on both the Bering and Pacific sides of Umnak Island. One individual left Unalaska Bay three days after tagging and moved ~1500km (in 12 days) along the outer Bering Sea shelf to the southern Chukotka, Russia. After 4 days, this individual moved east across the Bering Sea basin to Navarin Canyon (60°30'N, 179°20'W), where it remained until transmissions ceased. This study provides evidence that while humpback whales aggregate in areas of predictable prey abundance (e.g. to the north of Unalaska/Unimak Islands), some individuals perform relatively long trips, presumably to explore other possible feeding grounds. Movement patterns may be individually variable, but may also be influenced by seasonal or inter-annual productivity and prey abundance.

Hemoglobin, packed cell volume, and dive characteristics from ribbon and spotted seals

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Hemoglobin and packed cell volume (PCV) levels are higher in deep-diving marine mammals than in terrestrial mammals; thus, marine mammals can store and transport more oxygen in the blood, which is an essential adaptation that allows them to make deep dives and stay submerged while foraging. The National Marine Fisheries Service has recently been petitioned to list four species of ice-associated seals found in Alaska waters as endangered or threatened under the Endangered Species Act, primarily based on concerns about global warming and the projected loss of sea ice habitat. Ribbon and spotted seals exhibit different diving patterns; ribbon seals generally make longer and deeper dives than spotted seals. In the spring of 2009 and 2010, blood samples were taken from ribbon seals (n=51) and spotted seals (n=45) captured in the Bering Sea. Ribbon seals have higher hemoglobin concentrations and PCVs than spotted seals for all age classes and both sexes. Mean hemoglobin levels for ribbon and spotted seals were 21.89±2.42 g/dl and 18.7±2.87 g/dl, respectively. Mean PCVs for ribbon and spotted seals were 62.5±3.5% and 56.0±4.8%, respectively. Data from 30 ribbon and 27 spotted seals tagged with satellite-linked recorders indicate the majority of spotted seal dives are less than 200 meters. Ribbon seal dives are distributed over a wider range of depths, with some dives exceeding 600 meters. These data provide important information about the diving capabilities of ribbon and spotted seals and are valuable in assessing how ice-associated seals may be affected by a changing environment.

Iliamna Lake Freshwater Seal Study: Characterizing Local Use Patterns, Local Traditional Knowledge, and Seal Population Ecology

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In response to concerns about the absence of information on the status of the seals found within Iliamna Lake, the tribal communities of Iliamna and Kokhanok, in partnership with Bristol Bay Native Association, UAA, ADFG, and NOAA have joined together to gather baseline information on seasonal shifts in abundance and distribution of the unique freshwater seal population inhabiting Iliamna Lake, and to document local traditional knowledge (LTK) from nearby communities that traditionally harvest seals from the lake. Findings from the aerial survey work are reported by our collaborator Dr. David Withrow from NOAA, and here we focus on the LTK portion of the project.

To gather local traditional knowledge about seals within Lake Iliamna, this project has recruited and trained local community members from Iliamna, Kokhanok and Newhalen to act as local research assistants and conduct in-person interviews with those persons within their community who have knowledge about the seals. These LTK surveys include sections on subsistence use, seal ecology (abundance, haulout locations, diet, behavior, and movements) and how the local communities have interacted with the seals (traditional and customary use patterns, and socio-economic factors that may be influencing these patterns). This integration is part of an ongoing effort to understand how the variations in environmental and socio-economic conditions impact everyday life in indigenous communities in Alaska. LRAs have also been trained to collect biosamples from seals harvested within their communities, and samples will be used to assess the genetic identity and health and condition of seals within the lake.

Modeling the impacts of climate change on fleet behavior in the Bering Sea pollock fishery

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Purely ecological studies have observed a northward shift in the distribution of arctic and subarctic marine species, and predict further shifts as the ocean warms. Utilizing a robust oceanographic, biological, and economic dataset, we find that when making predictions about capture fisheries (as opposed to fish stocks), it is crucial to consider the profit maximizing behavior of harvesters. Commercial fishermen choose where to fish based on observable and unobservable characteristics of the area and the fisher, including the expected revenue in an area, fuel and fish prices, the distance to areas, vessel characteristics, institutional factors, and environmental conditions. We develop an empirical model to investigate the behavior of the catcher-processor (CP) sector of the Bering Sea pollock fishery, which is the largest commercial fishery in the United States and the largest food-fish fishery in the world. The catcher-processor sector accounts for approximately half of the total catch obtained from the fishery (about 500,000 metric tons and and ex-vessel revenue of about $500 million in 2008). The fish caught by the CP vessels is immediately processed into products such as fillets, surimi (an intermediate product used to make other products including imitation crab meat), and roe in a factory onboard the vessel. While a vessel's optimization of profit involves the standard maximization of total revenues less total costs, in this fishery revenues are a function of expectations about the prices that can be received from the various productions that can be produced from the catch as well as expectations about catch-per-unit effort (CPUE) over the extent of the Bering Sea.

This research is one component of the Bering Sea Integrated Ecosystem Research Project (BSIERP), a broad and inter-disciplinary investigation of the effects of climate change on the Bering Sea. Key among these effects is the role of climate on fish location and abundance and the impact that weather plays in daily participation and location choices for vessels. The spatial economic model incorporates climate data (for example, ice cover and sea surface temperature) into the model, permitting us to determine the relative impact of observable contemporaneous environmental conditions on location choices. We include predictions of changing pollock abundance in the model, which directly affect the total allowable catch (TAC) available to the fishery. This allows us to predict fisher responses to scenarios developed by oceanographic and ecosystem modelers involved in Bering Sea project.

Ingalimuit Traditional Knowledge of Walrus in Bering Strait

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This poster will outline a project about Little Diomede Hunters and Elders Knowledge of Walrus. This project utilizes published and un-published archeological, ethnographic, linguistic, historic, and archival data from the Bering Strait region in addition to Local Expert interviews, and linguistic research with expert Little Diomede hunters and elders living in the regional hub community of Nome and on Little Diomede Island. We will examine the cultural-ecological relationship between humans and walruses to document: 1) historic observations and changes in behavior and abundance of walruses in response to environmental phenomena; 2) historic human community adjustments to changes in behavior and abundance of walruses; 3) recent changes in walrus ecology in response to human and environmental factors and the linkages between these recent changes and historic hunting practices. Through these inquiries we seek to elucidate the cultural and ecological relationships between Little Diomede people and walrus which forms the basis for traditional knowledge, hunting resource management, and usage.

Salmon and Identity in the Bering Strait Region of Alaska

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This poster outlines my dissertation research on the topic of the relationship between salmon and identity in an Eskimo community in the Bering Strait region of Alaska. This research seeks to illuminate what role salmon plays in individual and group identity for the residents of and community of Elim. Research questions will be addressed through a variety of data collection and analysis methods such as archival research, free listing, ethnographic interviews, participant observation and cultural consensus analysis. Preliminary results from phase 1 of the research are presented.

The Historic Bering Sea Seal Industry: Characterizing Fleet Behavior in the North Pacific Fur Seal Trade

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This project will review literature relating to participant identity and harvest practices in the pre-1900 North Pacific fur seal trade. The preliminary research question is: What were typical characteristics of the early Bering Sea fur seal fleets? Subsequent questions include: Are these characteristics comparable to contemporary fleets and, if so, how is this relevant to understanding current social/ cultural issues related to fishery access, availability and closures in North Pacific commercial fisheries?

I hypothesize that historic fleet structure, industry identity and culture will contain some similarities to contemporary fleets and that references to historic literature will provide insight to industry transitions over a longer time period than usual in the social dimensions of fisheries research. This data retrieval will expand general understanding of social-ecological transitions in the North Pacific and contribute to the existing database of commercial fisheries research.

The investigation will consider the decline of the seal population by cataloging features of fleet harvest behavior and norms and the varied consequences of land versus pelagic sealing techniques. In many cases, access to information within these fields will be difficult to attain as a result of publication scarcity and I expect to utilize material related to industry descriptions in other substantial historic international fisheries such as cod and whaling. This will necessitate assumptions of similarity across commercial marine resource harvesters and although some differences are likely; I will refer to previous research in human dimensions of marine resource harvest to analyze and ascertain comparisons.

Research will focus on ports and commerce in locations outside of Alaska; urban cities such as San Francisco and Seattle were typical homeports for early Alaskan commercial fleets, independent companies and regulatory management. Preliminary citations will include University of Alaska archival accounts and imagery, University of California's Calisphere, federal government records, historic journalism and media.

Using Stakeholder Input to Identify Priority Data and Information Needs for Ecosystem-Based Management of Living Marine Resources in the Aleutian Islands Region

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Stakeholder input was used to identify priority data and information needs for ecosystem-based management of living marine resources in the Aleutian Islands Region. A combination of web-based surveys and interviews were used to gather stakeholder input on data and information needed for ecosystem-based management of living marine resources in the Aleutian Islands Region. Input received from 124 individuals and groups yielded 1,007 unique suggestions of research and information needs. The suggested research and information needs were organized under the six societal themes identified in the Ocean Research Priorities Plan: Stewardship of Natural and Cultural Ocean Resources; Increasing Resilience to Natural Hazards; Marine Transportation and Security; The Ocean's Role in Climate; Improving Ecosystem Health; and, Enhancing Human Health and Safety. A panel of experts rated the suggested research and information in terms of importance and feasibility using a variant of the Analytical Hierarchy Process. Preliminary results and sensitivity analyses will be presented.

Subsistence Harvest Monitoring Results on St. Paul Island, Alaska from 1999 to 2009

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Unangan (Aleuts) are customary traditional hunters-consumers of laqudax [northern fur seal (*Callorhinus ursinus*)] and qawax [Steller sea lion (*Eumetopias jubatus*)] in the Bering Sea. Traditional monitoring was part of a "take only as needed" system that effectively met community needs. Modern management needs require accurate recording of harvest information. Subsistence harvest monitoring was conducted on fur seal and seal lion for 2008 and 2009 under the Local Traditional Knowledge component of the Bering Sea Integrated Ecosystem Research Program. Harvest data from prior years was added to this data set to provide a comprehensive picture of 10 years of annual subsistence harvests of fur seal and sea lion. Harvest monitoring was conducted using a real-time monitoring versa a retrospective survey method. Real-time harvest monitoring involves a combination of volunteer and required hunter reporting and active monitoring and engagement with subsistence hunters. The results show annual harvest results and trends for fur seal and sea lion for the 10-period. These locally-generated data are reliable and cost effective, and are valuable for long-term monitoring of subsistence harvests and will provide temporal and geographic distribution of harvest of various species by sex and age class.

Primary Production experiments in the eastern Bering Sea: uptake rates of 13C during late summer/ fall 2006-2009

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With the goal of understanding the role of primary production during late summer/ early fall in the eastern Bering Sea, we compare uptake rates of 13C at the surface and at the depth of the phytoplankton maximum, across oceanographic domains on the northern and southern Bering Sea shelf. Primary Production may vary across domains due to differences in community composition, stratification and nutrient availability. Simulated in situ primary production experiments using water samples enriched with stable isotopes of carbon (NaH13CO3) were carried out during late summer /autumn surveys in the eastern Bering Sea, by the Bering Aleutian Salmon international Surveys (BASIS) program at NOAA. Uptake rates were compared among shelf regions (Inner, Middle and Outer Domains), latitudes and light levels. Preliminary analysis suggests surface uptake of 13C normalized to chlorophyll a, were higher at Inner Domain stations. Variations in uptake rate may be associated with shifts in phytoplankton community composition across Domains. The results of this research will further our understanding of late summer/ fall primary productivity and potential impacts on other ecosystem components in the eastern Bering Sea.

Modeling processes controlling the on-shelf transport of oceanic mesozooplankton populations in the Gulf of Alaska and SE Bering Sea

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Oceanic interzonal copepods are large-bodied high-energy crustaceans that can provide an important food source for a variety of planktivorous fish. However, they require deep water to successfully reproduce and therefore tend to occur in oceanic and shelf-break habitats geographically removed from many commercially important coastal fish stocks. Annual differences in year class strength of forage and commercial fish stocks such as herring, pollock, capelin and salmon may therefore depend on climatic and oceanographic conditions promoting cross-shelf transport of oceanic copepods to coastal regions where they are fed on by larval and juvenile stages of the above fish species. However, specific conditions promoting or suppressing on and cross-shelf transport in the Gulf of Alaska (GOA) and Bering Sea (BS) are poorly understood. Using a modified float track model and a Nutrient-Phytoplankton-Zooplankton (NPZ) ecosystem model fully coupled to three-dimensional oceanographic models (ROMS) for the two regions we explore the climate-driven mechanistic processes driving the timing and magnitude of transport of oceanic zooplankton onto the continental shelves of the SE Bering Sea and the Gulf of Alaska. Our experiment reveal that wind strength appears to be the primary driver controlling the advection of the zooplankton `floats' onto the shelves. Here we present a validation of the model float tracks with observational drifter tracks and explore the impact of wind forcing on the skill of the float simulations.

The source of nitrate deficit in Bering Sea Shelf waters

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We have investigated the N deficit in Bering Sea shelf waters, i.e. the deficit relative to the mean oceanic N:P using N-star (N-star = N – 16PO_4 +2.9; where N=[NO_3 + NO_2 + NH_4]). An approximately north-south section along the 70 m isobath revealed a persistent Ndeficit. During the spring the deficit was about 700 mmoles N m^{-2} in the north, decreasing to 400 mmoles N m^{-2} in the south, whereas during the summer, the deficit decreased to 550 mmoles N m^{-2} in the north and 200 mmoles N m^{-2} in the south. During spring the water column was mainly well mixed while in the summer a well-developed mixed layer persisted throughout the study region. Interestingly, the bulk of the decrease in the nitrate deficit from winter to summer took place in the mixed layer, while the nitrate deficit in the lower layer remained more or less constant. The decrease in nitrate deficit in the surface layer is likely due to some combination of advection of low deficit water from the coast or open Bering Sea and non-Redfield nutrient uptake. Over the winter, the nitrate deficit in the surface was reestablished by to sedimentary denitrification and some advection from offshore. During 2010 we determined sedimentary denitrification rates at 15 stations located throughout the shelf. Denitrification rate averaged about 0.5 mmoles N m^{-2} d^{-1} in spring 2010 and were likely higher during the summer. This denitrification rate would be sufficient to reestablish half to possibly all of the observed deficit

Ellavut/Our Yup'ik World and Weather

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"Ellavut/Our Yup'ik World and Weather" is based on gatherings with Yup'ik elders between 2000 and 2008 sponsored by the Calista Elders Council (the primary heritage organization of southwest Alaska) and funded by the National Science Foundation. It documents the qanruyutet (instructions and admonishments) that continue to guide Yup'ik interactions with the land and sea. The book's ten chapters reflect gathering topics, including weather, land, lakes and rivers, ocean, snow, ice, survival, and environmental change. Elders' concern has always been that young people understand how to treat one another. Yet elders also suffer over the fact that contemporary young people lack knowledge of ella--translated variously as weather, world, or universe--which many continue to view as responsive to interpersonal interaction. Elders actively support the documentation and sharing of traditional knowledge, which all view as possessing continued value in the world today.

Eelgrass Assessment and Monitoring using Remote Sensing and Field Survey Techniques in Southwest Alaska

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Eelgrass (*Zostera marina*) is an essential component of coastal and estuarine ecosystems that needs monitoring due to its susceptibility to direct human impacts and sensitivity to climate change. The southwest coast of Alaska provides an opportunity to study the response of arctic eelgrass beds to increased ocean temperature, more severe winter storm activity and decreased shorefast ice extent and duration. The U.S. Geological Survey and U.S. Fish & Wildlife Service have initiated an inventory and monitoring program to assess changes in eelgrass abundance and distribution at four national wildlife refuges: Izembek, Togiak, Alaska-Becharof and Yukon Delta. Remote sensing techniques were established, using Landsat satellite imagery and aerial photography, to map eelgrass distribution and to estimate the spatial extent of each of the detected beds. Field survey protocols were developed to ground truth the remote sensing products and provide a more detailed description of shoot morphology and bed characteristics such as density, biomass and associated species. Preliminary analyses indicate significant differences in biomass and species composition between beds to the north and south of the Alaska Peninsula (Bering Sea vs Gulf of Alaska) and predictable changes in shoot morphology as the sites progress to the north. The foundation of these methodologies and baseline datasets provide the ability to track changes in the health of eelgrass beds and the estuarine ecosystem.

"Calorie-Sheds" of Subsistence Harvests: Togiak, Alaska, case study

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Subsistence harvests draw on a wide range of resources. Much attention has been given to subsistence use areas—the places people hunt, fish, gather, and travel—but little attention has been given to the areas over which the subsistence species range. The "calorie-shed" is the spatial extent of the food web of which subsistence harvests are the apex. In this first attempt to delineate a calorie-shed, we use the top marine resources harvested at Togiak, Alaska, according to a 2008 harvest survey conducted by the Alaska Department of Fish & Game as part of the Bering Sea Integrated Ecosystem Research Program. Using available data on the ranges and migrations of the species in question, we compiled a map of the first-order calorie-shed for Togiak. Further work is needed to determine the range of the stocks or populations actually harvested in Togiak, should those differ from the overall species range, and to trace the calorie-shed further down the food web. Other approaches to consider include weighting according to level of use of the species in question, or according to intensity of use of a particular location by that species. Producing calorie-shed maps for other communities will allow comparisons to determine different spatial domains of harvests. The maps can also be used to identify potential impacts from human activity and environmental change.

Importance of ice algae on pelagic and benthic consumers in the Bering Sea

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The Bering Sea as a seasonally ice-covered sub-arctic sea is strongly influenced by climatic changes, especially the predicted loss of seasonal ice cover. One of the contributions of sea ice to the Bering Sea is a strong pulse in ice algae early in the season as food for plankton and benthic communities. Our purpose was to investigate the importance of ice algae as an early food pulse to various pelagic and benthic consumers using d13C and d15N stable isotope ratios. We compared stable isotope ratios of similar consumer communities at locations with different length of ice cover (57º – 62º N); isotopic composition did not differ among the three communities collected in early April 2008. Similarly, we investigated changes in isotopic composition in pelagic and benthic consumers at the southernmost location (57º N) in two week intervals, representing situations of complete ice cover, marginal ice cover and no ice cover. Again, no differences in isotopic composition were detected over this time frame. We suggest that slow turnover times in Arctic consumers, particularly muscle tissue, are responsible for these results.

How is the recent arrival of red foxes affecting the millions of birds that nest on the St. Matthew Islands, Bering Sea?

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Red foxes, *Vulpes vulpes*, have reached and established a breeding population on the St. Matthew Islands in association with climate warming in recent decades. During an expedition to these islands in 2005 the red foxes were observed to be suppressing the native arctic fox, *Alopex lagopus*. The St. Matthew Islands are part of the Alaska Maritime National Wildlife Refuge that support millions of colonial nesting sea birds, as well as ground nesting species, including the endemic McKay's snow bunting, *Plectrophenax hyperboreus*, and a major portion of the total population of rock sand pipers, *Erolia ptilocnemis*. An endemic singing vole, *Microtus abreviatus*, inhabits these islands and it was observed to be a primary prey species of the foxes. Complex questions for conservation of the life forms present in this island ecosystem are posed by the addition of a new mammal species. How do red and arctic foxes differ in their predatory behavior and what are the consequences for colonial and ground nesting birds and the endemic vole? Will the red foxes ultimately extirpate the arctic foxes? Will an insular red fox population be sustainable in a changing climate with projected increased frequency and severity of winter storm events?

COMIDA: What determines spatial distribution of epibenthic communities in the Chukchi Sea?

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The goal of the epibenthic component of the COMIDA (Chukchi Sea Offshore Monitoring in Drilling Area) study is to undertake sampling to monitor epibenthic communities associated with areas of potential and/or actual offshore drilling in the Chukchi Sea. This component conducted beam trawls and sampling of various environmental parameters at 53 stations within the study area in the summers of 2009 and 2010. A total of 45 genera (or higher) were sorted, identified, counted, and weighed from the stations. Although the area was fairly biologically homogenous, stations did segregate based on the dominance of *Echinarachnius* sp. (sand dollars), ophiuroids (brittle stars), and *Chionoecetes* sp. (snow crabs). Interestingly stations that were located close together did not necessarily contain the same dominant organisms, indicating some patchiness in the system. This patchiness is in part dictated by various environmental parameters including sediment grain size and bottom water temperatures. In some areas, the great abundance of some organisms, particularly the sand dollar *Echinarachnius* sp., may be associated with the high availability of sediment chlorophyll.

Chum salmon (*Oncorhynchus keta*) scale growth as an indicator for age-1 walleye pollock (*Theragra chalcogramma*) production in the Bering Sea, 1988-2009

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An ecosystem-based fisheries management requires the development of biological time series for ocean productivity for use in stock assessment and recruitment forecasts for commercially important species. Because the marine growth rates of Pacific salmon (*Oncorhynchus* spp.) are regulated by physical, biological, and population processes in the North Pacific Ocean and Bering Sea, the growth rates are indicators of past ocean productivity. The hypothesis is that growth patterns on the scales of chum salmon are biological indicators of variations in climatic and oceanic conditions experienced by age-0 walleye pollock (*Theragra chalcogramma*) and predict the recruitment of pollock to age-1. Scales were collected from chum salmon sampled by National Marine Fisheries Service Observers on-board vessels in the commercial fisheries in the Bering Sea (1980-2007). Spacings between circuli and annuli on the scales of chum salmon, a proxy for ocean productivity, in year t are used as a predictor for the estimated biomass of age-1 pollock in year t+1 in the Bering Sea.

The Bering Sea Integrated Ecosystem Research Program (BSIERP) Data Management Support: Continuing Preservation and Access

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The National Center for Atmospheric Research (NCAR) Earth Observing Laboratory (EOL) Computing Data and Software (CDS) Facility is working with the North Pacific Research Board (NPRB) to provide ongoing data management support to the Bering Sea Integrated Ecosystem Research Program (BSIERP). EOL will provide key data management support services to all BSIERP investigators who have or will be submitting data to an archive. EOL/CDS will customize infrastructure capabilities of the EOL Data Management System to provide support services including:

• Consolidation of the BSIERP archive with the NSF supported Bering Sea Ecosystem Study (BEST) archive at EOL
• Assistance to the investigators with dataset, documentation and metadata preparation, formatting and submission to the archive
• Provision web based information on BSIERP data procedures

We will support the seamless continuation of the archival of metadata and data for BSIERP to better match EOL standards and methodologies for data sets already archived as part of BEST. EOL will facilitate data and documentation submission, archival and sharing among BEST BSIERP and the larger science community. The goal is to provide a long-term, consistent, well-documented archive with “one-stop shopping” for locating and obtaining BSIERP and BEST data, and is a next logical step for the interoperability and synthesis of data collected by the BSIERP and BEST science teams. EOL will work with the NPRB to maintain archival and access to the complete BSIERP program data set and provide a legacy of data from over one hundred scientists working for five years on the Bering Sea Project.

We will describe the support process to retain the existing BSIERP data archive, improve integration with the BEST Project archive and discuss future steps to support this rich dataset.

Marine regions in the Eastern Bering Sea

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The Bering Sea Project brings together over 100 scientists and 35 projects in field research and ecosystem modeling to link climate, physical oceanography, plankton, fishes, seabirds, marine mammals, humans, traditional knowledge and economics. Its geographic extent spans the Eastern Bering Sea shelf and slope from the Alaska Peninsula to the limit of the U.S. Economic Exclusive Zone with Russia. In order to synthesize results of the program we set out to delineate regions that would provide a common spatial reference across the projects. Recognizing there is no single discipline for which there is data covering the entire geographical expanse of the program, we looked for a consensus among scientists based on oceanography, bathymetry, benthic fauna, fish, seabird and marine mammal distribution, as well as established survey strata and defined ecological domains (as for the Pribilof Islands). The result were 16 regions: 1) Alaska Peninsula, 2) South inner shelf, 3) South middle shelf, 4) South outer shelf, 5) Pribilofs, 6) Midnorth middle shelf, 7) Midnorth inner shelf, 8) North outer shelf, 9) St. Matthews, 10) North middle shelf, 11) North inner shelf. 12) St. Lawrence, 13) South Bering Strait, 14) Norton Sound, 15) Off-shelf north and 16) Off-shelf southeast. Rather than strict biogeographic domains, these regions represent a negotiated practical spatial division weighted by the spatial aggregation of biological data and/or large-scale oceanographic characteristics. We propose these regions as a summary of current knowledge of the general mesoscale structure of the Eastern Bering Sea shelf.

Faunal Zones of Nushagak Bay, Alaska

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Near shore marine and estuarine habitats in western Alaska have received little attention despite their ecological important. This paper maps the faunal zones of Nushagak Bay, a large estuary covering about 80 km2 located in southwestern Alaska. The estuary is the terminus of four large rivers including the Nushagak, Wood, Igushik, and Snake Rivers. It trends north to south and is turbid and tidally dominated. As the host one of the world's largest sockeye salmon runs it has been studied primarily in terms of sustaining salmon fisheries and not in terms biodiversity. During the summers from 2007 to 2010 the Bristol Bay Environmental Science Lab made 35 otter trawls that sampled over 70,000 m3. Throughout the estuary the dominate species in numbers and biomass include bay shrimp (*Crangon* sp) and Gammarid amphipods (*Gammarus* sp.). Fin fish species are more specific to faunal zones and salinity but wide-spread species include the starry flounder (*Platichthys stellatus*) and Spinyhead sculpin (*Dasycottus setiger*). We found that estuary fauna can be divided into 4 zones based on salinity, tidal current strength (turbidity) and bottom sediments. The entire estuary was found to have a low Shannon Diversity (H') value of 1.54 but diversity increase southward and as salinity increases. When compared to other sub Arctic estuaries the diversity of Nushagak Bay is low. This is most likely due to its low salinity, strong currents, and high turbidity.

Eualaria fistulosa holdfast communities in areas of high and low macroalgal abundance

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Eualaria fistulosa is the only canopy forming kelp in the Western Aleutian Archipelago and provides habitat for a variety of macrofauna. The objective of this study was to analyze the macrofaunal communities of *E. fistulosa* holdfasts in areas of high and low macroalgal abundance. The benthic nearshore environment of the central Aleutian Islands generally exists in two states of grazing pressure. When grazing pressure is low, the nearshore is dominated by kelps. Alternatively, when grazing pressure is high (due to an abundance of the green sea urchin, *Strongylocentrotus polyacanthus*), the nearshore is dominated by barrens that contain very few kelps. ANOSIM analysis revealed significant differences in the holdfast communities collected from kelp forests and barren grounds at Adak Island. Barren ground holdfasts supported more abundant and diverse communities than kelp forest holdfasts. In total, 81 taxa of invertebrates were found from 10 phyla. Polychaete worms and amphipods were the most abundant and diverse organisms observed in both habitats. Regression analysis revealed significant linear relationships between holdfast volume vs. biomass, diversity, abundance, and species richness. *Eualaria fistulosa* holdfasts support a diverse community of macrofauna that may be structured by the nature of the surrounding habitat.

Creating a Modern Map of Submerged Beringia – The Bridge that Endures Time

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An enduring link between Asia and North America remains submerged beneath the waves of the Bering Sea and Chukchi Sea. Historical efforts to map undersea Beringia have relied upon scant bathymetric data collected by early explorers and occasional scientific expeditions. Modern era hydrographic surveys using vastly improved navigational and multibeam sonar technology have covered significant portions of submerged Beringia in intricate detail. We will present output of our efforts to date to develop a geospatial database compiling the best available data from US, Russian and other sources to create a modern seafloor map of submerged continental shelf.

Both the visual map of modern underwater Beringia and the database generated through this project will serve as a resource for archaeologists whom continue to examine terrestrial and waterborne routes for human and other migrations between the continents. It will also serve as a significantly updated geospatial reference for biologists, geologists and other scientists eager to examine undersea life during and subsequent to climatic regimes dominating the area during past glaciations.

Examples of using global climate models for Bering Sea marine ecosystem projection

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Climate projections at regional scales are in increased demand from governments, management agencies and other stakeholders. While Atmosphere-Ocean General Circulation Models (AOGCMs) provide credible quantitative estimates of future climate at continental scales and above, the projections at regional scales have larger spread and uncertainty. Individual model performance varies in different regions, on different variables, and for different evaluation metrics. Taking the Bering Seas as examples we demonstrate that the core of the procedure for selecting a useful subset of models for regional projections is a comparative evaluation based on observational constraints at both the continental and regional level. Examples of sea-ice, surface air temperature, sea surface temperature projection for Bering Sea are used to illustrate the strategy, and the projections will be provided based the selected sub-set models under different emissions scenarios (A2, A1B, and B1). The outputs from these climate models also provide necessary information for regional dynamical/statistical downscaling, which can give quantitative estimate of potential impact of climate change on fish and fisheries.

Physiological Ecology of *Calanus* in the Bering Sea During Spring Sea-Ice Conditions: Feeding, Reproduction, and Population Genetics

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Our goal is to understand the impact of changing sea-ice conditions on planktonic food web structure and function by describing mesozooplankton and microzooplankton trophic linkages and the fate of phytoplankton blooms in the Bering Sea during spring. During three spring research cruises in 2008, 2009 and 2010, as part of the BEST-BSIERP program, we conducted experiments with dominant mesozooplankton to determine grazing rates on phytoplankton, ice-algae, and microzooplankton. Copepods in the genus *Calanus* exhibited a saturating feeding response to increasing chlorophyll concentration. However, they strongly preferred microzooplankton to phytoplankton/ice-algae, even at high chlorophyll concentrations, when feeding on natural assemblages. Based on enriched treatments with ice-algae, it appeared that they could significantly increase their ingestion rates by feeding in close association with the ice. Egg production rate (EPR) experiments with reproductively active copepod species were also conducted. The EPR of *Calanus* was asymptotically related to both ingestion rate and ambient food concentration, indicating that reproduction was not fueled by lipid reserves but depended on ingested food. These rates were strongly correlated with spawning frequency suggesting that food limitation had a stronger influence on inter-clutch interval than on clutch size. There was no evidence of egg-hatching inhibition due to feeding on diatom blooms; hatching success was 75-100% at all locations. In addition, sequence analysis of several different genes revealed a strong latitudinal gradient in the *Calanus* population/species structure. *Calanus glacialis* was found to be present on the shelf in much higher abundance and over a much greater area than previously thought.

Determining Methods for Individual Measurements on Trawled Jellyfish

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The annual Bering Aleutian Salmon International Survey (BASIS) targets juvenile forage fish, as well as lower trophic levels in the eastern Bering Sea in August through October. Jellyfish have emerged as species of interest due to an apparent increase in abundance worldwide. Jellyfish have been identified as a substantial component of the catch in the BASIS surveys. The jellyfish typically encountered in the trawl are *Chrysaora melanaster*, *Cyanea capillata*, *Aequorea* sp., *Staurophora mertensi*, *Phacellophora camtschatica*, and *Aurelia labiata*. Methods are being implemented to accurately account for their presence in the BASIS project. Starting in 2004, all large jellyfish caught by trawl were identified to species, measured for bell diameter, and weighed in groups. In 2006, bell heights and individual weights were added to the methods as a way to determine jellyfish condition. And in 2007, in an effort to explore bell diameter measurement error, individuals of two species of jellyfish caught were measured 4 different ways; “bell up” verses “bell down” and “true edge” verses “true bell”. Preliminary results indicate that bell height is not necessary to collect and that more types of bell measurements are needed for each species. Data collection is ongoing and will continue in August 2011.

A satellite-tracked drifter perspective of the nearshore Bering Sea: science and community involvement

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The Bering Sea's inner shelf (<30 m) circulation is poorly known, but it is a critical habitat and migratory corridor for marine organisms and links coastal rivers with mid-shelf waters. The residents of Quinhagak (Kuskokwim Bay) deployed 64 satellite-tracked drifters between June and October in 2008 and 2009, in clusters of 4 drifters at ~2-week intervals, to elucidate the time-varying circulation of the inner shelf.

Inner shelf flow variations respond to tides, winds, and coastal freshwater discharge, although the bulk of the non-tidal variability is wind-forced. Summer winds are weak and variable and the inner shelf flow is weakly northward. Winds are strong and northerly in fall, forcing a westward cross-shelf flow. That flow has short (~2 days, 10 km) integral time and decorrelation length scales, which reflect passage of storms.

The seasonal partitioning of the flow has important ramifications for this marine ecosystem. Passively drifting organisms move northward along the coast of western Alaska in summer, but offshore through fall. The seasonal flow transitions also affect the salt and nutrient budgets for the Bering shelf, because the fall offshore flow carries dilute, nitrate-poor, inner shelf waters onto the mid-shelf, where the mean flow is sluggish. Hence, coastal waters may remain here through spring and thus affect the mid-shelf nutrient reservoir during the spring bloom. Our results demonstrate that the inner shelf, which is inaccessible to many vessels, can be studied efficiently through collaborations with local communities.

Spatial distribution of stratification and age-0 walleye pollock on the Bering Sea shelf from 2003-2010

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Water column stratification determines the vertical distribution of water mass properties and is a key parameter for primary production and the food web of any marine ecosystem. Recruitment success of walleye pollock on the southeast Bering Sea shelf has previously been shown to be negatively correlated with stratification. Stratification shows considerable temporal and spatial variability, and is dependent on sea ice extent and retreat as well as on the distribution of heat and freshwater through oceanographic shelf processes.

Cumulative distribution functions of stratification, computed from temperature and salinity profiles, and relative abundance of age-0 walleye pollock, determined from surface (0-18 m) net trawls carried out during BASIS (Bering-Aleutian-Salmon-International-Surveys), are significantly correlated, indicating that young pollock are most abundant in stratified waters. We present spatial observations of stratification and age-0 pollock relative abundance from BASIS surveys from 2003-2010.

Can we use a coupled biophysical IBM model experiment to predict recruitment of snow crab in the Bering Sea – The Gate Hypothesis

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We present a model experiment exploring possible reasons behind variability in snow crab recruitment in the Bering Sea, and potential applications to snow crab management. We used a set of coupled models to examine the Gate Hypothesis: "Recruitment success in snow crab is dependent on (1) the initial larval release location, (2) overlap of larvae with ice-edge blooms, and juvenile settlement in areas where (3) bottom temperatures are between 0 and 2ºC, and (4) few cod predators are present". We used an IBM-ROMS model of larval crab biology and movement to predict the transport pathways of larvae, and bottom temperature at the location of settlement. We combined this information with a statistical model of the timing and location of the ice-edge bloom (to predict the overlap of larvae and blooms, and the total chlorophyll encountered in these areas), and a data-based description of the biomass and diet of cod in the areas where juvenile snow crab were predicted to settle by the IBM. We used GLM and GAMS models to compare these factors with estimates of crab recruitment. We found that the proportion of larvae settling in the eastern Bering Sea, the mean latitude and longitude, and mean chlorophyll encountered were significant variables (R-sq(adj) = 0.756). Stronger recruitment years showed more settlement in areas where bottom temperatures were between 1.3 and 2 ºC and less cod in areas of settlement, however these factors were not significant. We discuss application of these results to management.

Development of a DNA-based assay for larval red king crab identification and quantification

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With a landed value of $265 million in 1980, the Alaskan red king crab (RKC) fishery was once one of the most economically important single-species fisheries in the world. The stock collapsed in the early 1980s and has not yet exhibited substantial recovery. Improvement in stock assessment methodologies would aid in development of RKC restoration plans; an understanding of life history and population dynamics is essential to stock assessment processes. For many marine species, including RKCs, the planktonic larval stage is the primary dispersive stage, therefore, larval dispersal and recruitment are important determinants of the structure and dynamics of marine populations. Our understanding of RKC population processes is constrained by our limited knowledge of larval biology. Crab larvae are temporally and spatially patchy in distribution and require extensive sampling efforts to track dispersal and gain an understanding of larval dynamics. Major impediments to analyzing the large numbers of plankton samples necessary to track movements are the time and expense required to sort samples and individually identify zooplankton via light microscopy. We are developing a DNA-based assay, using quantitative PCR for the simultaneous identification and enumeration of RKC larvae in plankton samples. We have identified probes sites, optimized reaction conditions, created a standard and begun spiking RKC-free plankton samples with larvae for determination of detection limits. The assay will eliminate tedious visual sorting, be less expensive and faster than morphological identification, permit the analysis of many more plankton samples than previously practical, and potentially be of use to the Alaska King Crab Research and Rehabilitation Program.

The Pribilof eddy in the eastern Bering Sea

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Eddies in the Bering Slope Current form along the shelf break of the eastern Bering Sea near Pribilof and Zhemchug Canyons. These eddies have been shown to influence nutrient and phytoplankton distributions. The eddies that form near Pribilof Canyon may be particularly important to upper trophic levels due to their proximity to the Pribilof Islands, an important breeding ground for fur seals and numerous species of seabirds. A Pribilof Eddy formed in April 1997, strengthened during spring/summer, moved off-shelf toward the southwest, and persisted until December. Water properties (temperature, salinity, chlorophyll, nutrients) within the eddy were sampled on multiple occasions in the summer of 1997. When first sampled in June, the eddy had a diameter of ~100 km and extended to ~2,000 m depth. Significant changes in the eddy properties were observed when it was subsequently sampled approximately a week later. In addition, eight satellite-tracked drifters, some of which included ocean color sensors, were deployed within the eddy resulting in months of Lagrangian data. Results from this 1997 Pribilof Eddy will be described in the context of interannual variability of eddy activity along the eastern Bering Sea shelf break from satellite altimetry data.

Temporal and Spatial Variability of Primary Production on the Eastern Bering Sea Shelf

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There have been relatively few studies on primary productivity of the eastern Bering Sea, and how this production varies in space and time. Such studies are vital in light of altered physical forcing in the Bering Sea that may already be underway as a result of changing climate. Estimating net community production (NCP) from seasonal changes in nutrients is the best approach for integrating primary production measurements over space and time. This approach is only valid for regions with low rates of advection. Using data from the past decade, we estimate the spatial and temporal variability of net community production from the drawdown of nutrients observed at hydrographic stations and moorings on the eastern Bering Sea shelf. From mooring data, we examine how presence or absence of sea-ice impacts production rates and the timing of the spring bloom in the south. From hydrographic data, we compare total NCP in the northern and southern shelf. Results from this study will be invaluable in forecasting the influence of climate change on the ecosystems of the Bering Sea.

Emergence of the Arctic hyperiid *Themisto libellula* on the southeastern Bering Sea shelf as a result of the recent cooling and their potential impact on pelagic food web

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The eastern Bering Sea shelf has been experiencing a sequence of extremely cold years marked by intense ice coverage and late ice retreat since 2008. Spatial and temporal variability in zooplankton communities during these conditions was investigated as a part of the collaborative BEST-BSIERP program. An increasing (an order of magnitude between 2008 and 2009) presence of the arctic hyperiid *Themisto libellula* , which has not been recorded in the study area since the 1970s, was observed on the middle shelf, indicating a developing structural shift in the zooplankton community in response to continuous cold conditions. Simultaneously, *T. libellula* became an increasingly dominant prey in salmon and seabird diets, suggesting the important role of the species in the pelagic food web. A voracious predator, *T. libellula* has been shown to be capable of controlling copepod populations; thus it may serve as a potential contributor to top-down regulation of the growing *Calanus* spp. population on the Bering Sea middle shelf during the recent cooling event.

Assessing the condition of walleye pollock *Theragra chalcogramma* larvae using muscle-based flow cytometric cell cycle analysis

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We developed an assay that measures the condition of walleye pollock *Theragra chalcogramma* larvae using flow cytometric cell cycle analysis of muscle cell nuclei. The assay was calibrated using laboratory-reared larvae of known condition reared over a range of temperatures that they are likely to experience in the eastern Bering Sea. A quadratic discriminant analysis model was formulated to classify a larva as healthy (feeding) or unhealthy (starving) using the fraction of cells in the S and G2 phases of the cell cycle, temperature, and standard length as covariates. Validation tests showed that the model classified 75% to 83% of the larvae correctly. Advantages of this assay are that sample preservation (frozen storage at -80ºC) and tissue preparation are relatively simple, and individual larvae can be quickly assessed. We assessed field–collected walleye pollock larvae from the southeastern Bering Sea in 2007 and found unhealthy larvae located on the continental shelf (6%). This may have been due in part to the coldest temperatures occurring there and low prey availability. In the continental slope/ocean basin waters, where prey levels were higher and temperatures warmest, no larvae in unhealthy condition were found.

Variability in macroalgal community structure along a longitudinal gradient and in relation to biogeographic breaks for the Alaskan Aleutian Archipelago

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Although macroalgal assemblages have many positive effects on coastal ecosystems, their health and extent have been declining worldwide. This demonstrates the importance for worldwide census projects such as NaGISA. The goal for this project is twofold. The first goal is to look at macroalgal abundance and biomass data collected as part of the NaGISA project, and determine the variability in macroalgal community structure along a longitudinal gradient from Unalaska to Attu Island along the Alaskan Aleutian Archipelago. The second goal is to determine the changes in macroalgal communities that follow known biogeographic breaks. The biogeographic breaks used for this study were Samalga, Amukta, Amchitka, and Buldir passes. Macroalgal surveys were conducted at various sites from 23 different islands. At each site, all macroalgae were removed from five replicate 50x50 cm random quadrats along a 30-50 m transect line at 5,10, and 15 m water depths. All macroalgae were then sorted to the lowest taxonomic level and weighed. Kelp species were also counted. Analysis of abundance and biomass data demonstrated that there was a great deal of variability among sites. There was no significant difference in abundance based on depth; however there was a significant difference for biomass. Analysis of community structure demonstrated a change in population dominance from *Agarum clathratum* and *Saccharina subsimplex* to the east of Amchitka pass, to mainly *Eualaria fistulosa* to the west. The results of this study provide a better understanding of the variability in macroalgal distribution to assess their health and extent.

A continuation of cold conditions in the Bering Sea: 2010

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The eastern Bering Sea remained cold in 2010, with extreme sea-ice extent and duration over the southeastern shelf. This contributed to the unusually cold sea-surface temperatures (<9.5°C) over the middle shelf during summer, and an extensive cold pool covering much of the middle shelf. Depth-averaged, summer temperature at mooring site M2 remained below 5°C. Historical records (1970s to present) indicate that up until 2000, the dominant mode of temporal variability during spring was year-to-year oscillations between cold conditions (presence of ice and cold integrated temperatures) and warm conditions (absence of ice in the southeast, warmer integrated temperatures). In 2000, there was a shift to warm conditions for ~6 years, and, beginning in 2006, a shift to prolonged cold conditions. The ecosystem appears to respond to multi-year periods of warm or cold differently than it does to the year-to-year variability. For instance, prolonged cold periods appear to allow increased concentrations of large crustacean zooplankton such as the copepod *Calanus* and the euphausiid, *Thysanoessa* that are important prey items for fish, seabirds, and cetaceans.

An evaluation of the estimation ability of the stock assessment method used in the eastern Bering Sea for snow crab given uncertainty in biological processes

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Snow crab (*Chionoecetes opilio*) in the eastern Bering Sea were declared overfished in 1999. The subsequent failure of the plan to rebuild the stock by September of 2009 calls into question the ability of the management system to achieve its goals. A key part of this system is the method used for stock assessment. However, it is unclear how well this method is able to estimate the quantities used in management (e.g. mature male biomass (MMB) and the overfishing level, OFL). A lack of data on some of the biological processes included in the population dynamics model on which the stock assessment is based compounds the difficulty of estimating important management quantities. As experimental studies with fisheries are often infeasible and/or undesirable, a simulation framework in which known populations are generated and then assessed was created to explore the estimation ability of the stock assessment method. Scenarios in which more or less information about key processes (growth, mortality (both fishing and natural), catchability, recruitment and selectivity) is provided to the stock assessment method were evaluated in terms of how well MMB and OFL are estimated. The results of this study could be used to inform management decisions given uncertainty in population processes, and to identify and rank key areas of research for snow crab.

Modeling ice-covered marine ecosystem in the Bering and Chukchi seas

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A Physical-Ecosystem (NPZD) Model (PhEcoM) was coupled to a Coupled Ice-Ocean Model (CIOM) and applied to simulate seasonal cycle of upper trophic level ecosystem processes with seasonal ice cover in the Bering Sea. The simulated circulation pattern and NPZD patterns are consistent with well-recorded measurements, such as the Green Belt along the Bering Slope Current, which extends to both Kamchatka Current and Anadyr Current system. The ice-ocean-ecosystem model can capture well the nutrient-rich Anadyr water and nutrient-poor Alaska coastal water, both of which advect the Bering waters with biologically-distinguished properties into the Arctic Ocean in terms of nutrient, phytoplankton, and zooplankton. Thus, the advection of the Bering waters into the Chukchi Sea would have significant impacts on Arctic ecosystems including food web, in particular, during the period of diminishing summer ice. Seasonal cycle of each compartment in several ecosystem sensitive areas is examined in depth. Sensitivity studies are also conducted to validate some emerging hypotheses.

Compound-specific stable isotope analyses of fatty acids in primary production from the Bering Sea: a foundation for food web biomarker studies

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The Bering Sea experiences the largest seasonal sea ice advances and retreats of any region in the Arctic and sub-Arctic. Climate-related changes in seasonal sea-ice cover will impact primary production patterns in the Arctic and likely be propagated through the marine food web. In particular, significant changes in the nutritional quality of fatty acids (FAs) derived from primary production in sea ice will likely impact upper trophic levels that are dependent on these resources. FAs have been used to study marine food web dynamics but more specific markers, such as compound-specific isotope analysis (CSIA) of FAs, originating from different sources of primary production are necessary to trace the relative importance of these sources to upper trophic levels. The goal of this study was to characterize the FA profiles and their compound-specific isotope ratios of arctic marine primary production in the Bering Sea. Sea ice algae and water-column particulate organic matter (POM) samples were collected in the Bering Sea between 14 April and 2 May 2009 and analyzed using CSIA. Results from the CSIA of FAs showed the δ13C of 14:0, 16:4n-1, 20:5n-3, and 22:6n-3 in ice algae to be isotopically enriched (~4‰) relative to those in POM, while 18:0 was depleted in ice algae (~2‰) relative to POM. These preliminary findings indicate that CSIA analysis will allow us to track the proportional contributions of sea ice algae and POM fatty acids into higher trophic levels (i.e., zooplankton, ice seals) in the Bering Sea.

Comparing gonadosomatic index and methyl farnesoate between shell conditions of eastern Bering Sea male snow crab *Chionoecetes opilio*

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Snow crab *Chionoecetes opilio* are a commercially important species supporting a male-only fishery in Alaska. The eastern Bering Sea (EBS) stock is managed to ensure all harvested males have at least one opportunity to mate before the fishery. This assumption may not be satisfied, as the molting process may compromise reproductive fitness of recently molted males. The goal of this project is to study how molting affects male snow crab reproduction by measuring reproductive indices before and after the terminal molt: hormones (methyl farnesoate, MF) and structures (gonadosomatic index, GSI). Terminally molted males are classified as “large-claw” (LC); non-terminally molted males are classified as “small-claw” (SC). Crustacean molting and reproduction are regulated by hormones that include ecdysteroids (molting) and MF (mating). Literature supports a relationship of significantly higher MF in reproductively active male crabs; we propose that MF levels will be lower in post molt “new-shell” crabs compared to “old-shell” crabs, or crabs that have not molted in at least one year. We sampled hemolymph to measure MF; MF will be quantified using high performance liquid chromatography (HPLC). We measured GSI, the ratio of gonad weight to whole crab weight, and compared GSI between the two shell conditions. GSI was significantly lower in new-shell males compared to old-shell males (ANCOVA, $p<0.05$). New-shell males are commercially valuable and targeted for their visual appeal over old-shell males. With reduced GSI, representing lower reproductive capacity, recently molted crabs may be harvested before contributing reproductively to the population.

Mechanisms of ecological resilience of Common Murre populations to climate change in the Bering Sea

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We investigated how climate change might affect population processes in common murres (*Uria aalge*), one of the most abundant top-predators breeding in the south-eastern Bering Sea. Previous studies suggest that seabird responses to environmental changes are localized and might depend on the genetic and demographic structure of a specific colony. Here we used a novel integrative approach that combines molecular, physiological, and behavioral tools to examine causal factors determining persistence of murres breeding on St. Paul and St. George (Pribilofs) and Bogoslof (Eastern Aleutians) Islands. During past decades murres breeding on these colonies have shown contrasting numerical trends - declining on St. Paul, relative stability at St. George, and increasing on Bogoslof - providing an ideal framework for our study. We compared the frequencies of different mtDNA haplotypes (based on ND2 sequences) and foraging behavior (based on stable isotopes signatures and stress hormone titers) of individuals breeding on these colonies. We found an increased proportion of mutations in ND2 in birds at Bogoslof as compared to the Pribilof Islands. Stress levels were higher in carriers of mutated ND2 genes compared to carriers of the nominal haplotype. We also found that on St. George I. carriers of mutant and nominal haplotypes had distinct stable isotope signatures of their blood, suggesting that they were foraging on different prey species. Our preliminary results suggest that the genetic structure of focal colonies, dietary preferences, and physiological tolerance of different phenotypes to nutritional stress might be the basis of the observed differences in numerical trajectories.

Comparison of stable isotope measurements from seabirds of the Near Islands, Aleutian Islands

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Stable isotope analyses are often used to infer migration patterns, diet composition and trophic status of seabirds. However, a variety of techniques are used to analyze stable isotopes among and within tissues, which potentially affect the results, their interpretation and thus the comparability of studies. One such difference is seen with the processing of lipids in samples. Tissues contain variable amounts of lipids which are depleted in the heavy carbon isotope (13C) and may introduce a bias in these values. While some studies extract lipids from tissues prior to stable isotope analysis, others do not. Additionally, there is evidence that lipid extraction may affect other stable isotope ratios, such as δ15N. Prior studies comparing lipid extracted tissues to non-lipid extracted tissues have found that differences in δ13C and δ15N values depend on the species and tissue type analyzed. Consequently, correction factors need to be applied to appropriately interpret δ13C and δ15N values for individual species. In this study, we collected seven species of seabirds from the Near Islands, the western most group of islands in the Aleutian Island archipelago. We sampled kidney, liver, heart and muscle samples from each bird and after freeze drying, individual tissue samples were divided into two subsamples. We left one subsample unaltered and extracted lipids from the other subsample using a 2:1 chloroform-methanol solution. We found that δ13C values varied among species and tissue type by as much as 1 %, while δ15N values remained fairly robust. Ultimately, the correction factors calculated for these seven seabird species will contribute to the growing body of knowledge regarding the effects of lipids on stable isotope ratios.

Correlating Black-legged Kittiwake and Thick-billed Murre distributions with environmental variables in the southeastern Bering Sea

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We documented the distribution patterns of Thick-billed Murres and Black-legged Kittiwakes in the southeastern Bering Sea during July and August 2009. Our study area encompassed three distinct island colonies (St. Paul; St. George; Bogoslof), during chick-rearing periods for murres and kittiwakes. Seabirds were surveyed in 10-kilometer strip-transects, with transects randomly assigned throughout the study area and equally apportioned through time. We conducted 114 transects, recording the number, behavior, and distance bins in which seabirds were sighted. Transects were first vetted for biases in detection distance due to strip width and sea state, and then binned into 2km horizontal segments. Seabird densities within each bin were correlated with physical and environmental features such as bathymetry, distance to nearest colony, distance to 300m shelf break, sea surface temperature, and Chl A. Spatial and temporal variables such as latitude, longitude, and time-of-day were also used to explain distribution patterns. Transect data was characterized as zero-inflated, and a hurdle model was used to interpret the influence of environmental variables on both the presence/absence of seabirds, and on the positive densities of seabird distributions. A standardized transect term was used to account for spatial autocorrelation within transects. For murres, Distance to Nearest Colony ($p<0.001$) and Distance to Shelf Break ($p<0.001$) were significantly correlated with bird presence, and Distance to Nearest Colony was also correlated with trends in positive bird densities. The presence of kittiwakes was significantly correlated with Sea surface temperature ($p<0.001$) and Distance to nearest colony ($p<0.01$), and positive density trends were marginally correlated with Sea Surface temperature ($p<0.05$) and Distance to Shelf Break ($p<0.05$).

Winter Seaduck and Gull Population Trends on the Pribilof Islands, Alaska

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Remote wildlife monitoring programs often focus on summer resident species, resulting in seasonal information gaps. A well designed community-based ecological monitoring program can fill this gap. Our goal here is long-term trends of winter seaducks and gulls on the Pribilof Islands, Alaska. Our choice of location is based on the capabilities of the Aleut Community of St. Paul Island-Tribal Government-Ecosystem Conservation Office. The Pribilof Islands are important winter habitat for several species of seaducks yet few data exist due to winter sampling logistics. Gulls are an invasive species, largely associated with anthropogenic activities (e.g. refuse and fishing), that pose significant impacts to native bird populations. Weekly counts were made from November through May at specific sites (26 in 2009; 36 in 2010; representing 9 regions on St. Paul Island) of eight seaduck and one gull species. Counts adhered to previous USFWS survey methodology where possible. Temporal and spatial frequencies are reported for 2009 and 2010 and contrasted with existing USFWS counts. The results show a consistency in annual timing trends between the two years and suggest that previous surveys were mostly not made during peak abundance. Gulls were primarily associated with human activity near the village, particularly dockside and outfall fish offal, and not the landfill. These locally-generated data are reliable and cost effective, and are valuable for: (1) minimum population estimates; (2) temporal distribution (within and among seasons); (3) geographic distribution (biased by access); (4) comparison with historical data (similar methodology); and (5) determining timing of full population counts.

Breeding Ecology of Kittlitz's Murrelet at Agattu Island, Aleutian Archipelago, Alaska, in 2010

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The Kittlitz's murrelet (*Brachyramphus brevirostris*) is one of the rarest breeding seabirds in the North Pacific and one of the least known in North America. During the final year of a 3-year study on the breeding biology of Kittlitz's murrelets at Agattu Island, we located and monitored 23 nests. We used a disturbed/control study design to investigate researcher impacts on chick survival. Time-lapse cameras were deployed at disturbed nests and used to quantify chick diets. Fishes provisioned to chicks varied among nests, as did the frequency of adult visits to nests. Of the 23 nests discovered in 2010, only three chicks fledged. All three chicks fledged at approximately 30 days; however, fledging mass of chicks ranged from 82 to 107 g. Our findings indicate that Kittlitz's murrelet chicks at Agattu have low growth rates, likely owing to low-lipid content fishes provisioned by adults. Overall reproductive success was low (2010 = 6 % of nests fledged) for the third consecutive year at Agattu. The continued study of the murrelets in the Aleutian Archipelago will provide further insight into the breeding biology of this rare and elusive seabird and provides a unique opportunity to elucidate its life history.

IDENTIFYING NESTING HABITAT OF KITTLITZ'S MURRELETS: OLD NESTS PROVIDE NEW CLUES

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The Kittlitz's murrelet is one of the rarest and least studied seabirds with only 23 nests having been discovered prior to 2005. After the discovery of 11 nests in 2006 at Agattu Island, Aleutian Archipelago, Alaska, we initiated a focused effort in 2008 to study the breeding ecology of this seabird. While revisiting known murrelet nests from previous years, we noted that nests which survived into the later stages of the brood-rearing period often contained a dense growth of mosses, grasses and/or forbs. Using these vegetative cues, we searched for 'non-active' nests, defined as nests used in previous breeding seasons but not monitored during our research efforts. Breeding use at these sites was confirmed by the presence of eggshell fragments, chick remains, and/or a fecal ring. At Agattu in 2009 and 2010, 25 and 35 non-active nests were located, respectively. We examined the broader application of using vegetative cues to locate non-active nests by searching possible nesting habitat at Adak Island during July and September 2010. Two non-active nests were discovered and provide the first confirmed breeding of Brachyramphus murrelets at Adak. The use of non-active nests for identifying breeding habitat of Kittlitz's, and possibly marbled murrelets, has great potential utility at other islands throughout the Aleutians and potentially elsewhere throughout their range.

Seabird distribution, habitat, and prey associations during non-breeding seasons in Alaska's Bering and Chukchi Seas

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For seabirds, fall through spring are critical periods for survival and fitness for reproduction, yet we lack basic knowledge of non-breeding distribution, habitat use, and prey associations in the Bering and Arctic seas. The ecology of northern oceans is closely intertwined with sea ice extent, and among the first detectable consequences of global warming will be changes in the icescape and prey availability. We present a preliminary examination of broad scale patterns of species composition, distribution, and habitat and prey associations. Our goal is to understand how seabirds use the post-breeding (August – October) and pre-breeding (March – May) environment. Seabird surveys were conducted in 2006-2010 as part of the BEST/BSIERP studies, covered >80,000 km and included forays into the ice pack. From August through October seabird species richness (~ 40 spp) and total density was high. For several key species, distribution shifted from outer to middle shelf domains or north into the Chukchi Sea, concurrent with low ice and an increase in forage fish and euphausiids in those regions. In March and April species composition (with ~ 20 spp), included surface feeders and divers along the ice pack's edge, with a smaller community of ~ 7 spp in the open leads and polynias within the ice pack. The few alcid species in the ice pack were in areas with amphipods and arctic cod. As ice retreated in May and early June, species richness (~ 30 spp) and density increased, particularly along the Bering Sea outer shelf, as krill, fish, and cephalopods increased.

Changes in the distribution of hotspots of pelagic seabird species diversity and abundance in the Bering Sea and North Pacific over four decades

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Using ship-based pelagic surveys from the North Pacific Pelagic Seabird Database, we examine the distribution of hotspots of summer seabird species richness and diversity at several spatial scales. We correct for heterogeneous survey intensity and discuss several diversity measures. Focusing on the Bering Sea, we calculate the diversity anomaly for each of the four decades. After smoothing and interpolating these anomalies we show areas in which diversity increased and decreased. We find that, with the exception of the shelf south of the Pribilof Islands, seabird species diversity has increased over most of the Bering Sea. Independently of scale, rarefied species richness is positively related to sea surface temperature, but negatively to primary productivity. Our results have implications to forecasting the effects of climate change on the Bering Sea ecosystem and its seabird communities.

Short-Tailed Albatross New Colony Establishment Phase 2: Post-Fledging Survival and Marine Habitat Use of Hand-Reared vs. Naturally-Reared Chicks Robert Suryan

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Once the most abundant albatross in the North Pacific, numbering over a million, the short-tailed albatross (*Phoebastria albatrus*, STAL) was hunted to near extinction. The population has since increased, yet still numbers less than 3,000 individuals (0.3% of historic levels) and breed on only 2 of ~14 historical islands. Re-colonization of a third island is required to remove STAL from the Endangered Species List. From 2006 to 2010 we completed Phase 1 of new colony establishment by developing albatross chick translocation and hand-rearing techniques using surrogate species and successfully completing three years of STAL translocation efforts. We are now entering Phase 2, the final years of translocations and continued experimental evaluation of recovery efforts.

The first three years of STAL translocations were remarkably successful, with 100% chick-rearing survival and 97% post-fledging survival – both metrics exceeding those for naturally-reared chicks. With additional data collection during the final two years of translocation, we will test: (1) whether apparent differences in migration and distribution of hand- vs. naturally-reared chicks persist and are significant; (2) the cause of possibly lower post-fledgling survival of naturally-reared chicks at the species' primary breeding colony; and (3) habitat use of fledgling vs. adult/subadult STAL and implications for fishery interactions. This project ultimately attempts to accelerate new colony establishment, while, quite unexpectedly, increasing survival rate of STAL chicks and possibly enhancing overall population recovery. The ultimate success of these efforts will depend on recruitment to the hand-rearing site and preliminary indicators from the surrogate species are very promising.

Status of Kittlitz's Murrelet in Russia

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The range of the rare Kittlitz's Murrelet (*Brachyramphus brevirostris*) is generally considered to be centered in Alaska, with a known but poorly-documented portion of the global population in Russian marine waters. Here we provide an overview of the distribution and conservation status of the Kittlitz's Murrelet population in the Russian Far East. Our assessment is based on surveys conducted by the authors from the 1970s to the 2000s, with a total survey distance of more than 10,000 km. These surveys covered the species' main Asian breeding area. The species is widely distributed in the Chukchi and Bering seas, where it is observed from de Long Strait to Kamchatsky Bay, and also in the northern Sea of Okhotsk. The northern boundary of winter distribution lies along the Sireniki polynya near the south coast of the Chukotka Peninsula. Migrating and wintering birds have also been recorded near the North-Eastern Sakhalin and Northern Japan islands. In the Bering Sea, highest densities were observed in the coastal waters of the eastern and southern parts of the Koryak Highlands and South Chukotka Peninsula. In the Sea of Okhotsk, Kittlitz's Murrelets occupy about 500 km of coastline from Amakhton Bay to Tavatum Bay. Taken together, our assessment shows that the Asian coast may support a significant part of the world population of Kittlitz's Murrelet, and we highlight the importance of collaboration with US researchers and managers in pursuit of research and monitoring priorities to better understand this species' role in the marine ecosystem.

Biological age as a link between behavioral patterns, physiological traits, and climate change in a Bering Sea top-predator

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The effect of climate change on top-predators in dynamic environments is a topic that currently interests managers, ecologists, and population biologists alike. Demographic information is crucial to understanding population dynamics of top-predators, yet is difficult to assess. In addition to snapshots of current population states, longitudinal data provide depictions of long-term trends. Yet banded populations remain rare and expensive to develop. Furthermore, genetics, individual histories, and ecological factors all influence life expectancy in such a way that biological, rather than chronological, age gives pertinent information about future trends. In this study we characterize demographic structure (biological age) of three colonies of thick-billed murres (*Uria lomvia*) by measuring telomeres of individual birds. Telomeres are DNA fragments that degrade with cell damage and age, providing a reliable proxy for biological age. Previous work with this species has established a baseline relationship of chronological age to telomere quantity using known-age murres from a Canadian colony. Murres are an abundant Bering Sea top predator, and they rely on the same food web as human harvesters and protected marine mammals. Here we define biological age for Bering Sea colonies experiencing different oceanographic conditions and population trajectories. Climate is likely to affect food availability, so to examine how age may influence foraging decisions in response to climate fluctuations, we compare individual stable isotope signatures and diving behavior in relation to their biological age. This study provides wildlife practitioners with a molecular link from behavior and physiology to factors that affect population processes.

AUTHOR INDEX